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Love Canal Emergency Declaration Area Habitability Study. Volume 3 Soil Assessment: Indicator Chemicals

CH2M Hill Southeast, Inc., Reston, VA

Prepared for

Environmental Protection Agency, New York

May 88

U.S. Department of Commerce
National Technical Information Service
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United States
Environmental Protection Agency

LOVE CANAL EMERGENCY DECLARATION AREA HABITABILITY STUDY

FINAL REPORT

VOLUME III

Soil Assessment-- Indicator Chemicals

TECHNICAL REVIEW COMMITTEE

U.S. Environmental Protection Agency Region II
U.S. Department of Health and Human Services / Centers for Disease Control
New York State Department of Health
New York State Department of Environmental Conservation

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Environmental studies were conducted to provide data that could be used by the Commissioner of Health for the State of New York in determining whether the Emergency Declaration Area (EDA) surrounding the Love Canal hazardous waste site is habitable. A soil assessment for Love Canal Indicator Chemicals was conducted. The soil assessment compared concentrations of the Love Canal Indicator Chemicals found in the EDA to concentrations found in similar western New York communities. An analytical technique was developed to detect the indicator chemicals at very low levels, i.e. 1.0 ppb. The analytical technique utilized a gas chromatograph/mass spectrometer operating in the selected ion monitoring mode. The analytical results were statistically compared between the EDA and the comparison areas using a modified Wilcoxon rank sum test. A comprehensive QA/QC program was implemented during the study and included detailed, uncommon QA/QC procedures and measures. Data was gathered electronically from data sources including field operations, laboratory operations, and data validation review, in an extensive data capture and integration system developed for the study.

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Page	Line	Erratum
A-3		"mean" should read "median"
A-5		"mean" should read "median"
A-8		Delete this page; it is a repeat of page A-6.
A-9	-19	"sampling area-" should read "EDA sampling area-"
	-16	"neighborhood" should read "sampling area"
	-13	"neighborhood" should read "sampling area"
	-12	"neighborhood" should read "sampling area"
A-10	10	"neighborhood" should read "sampling area"

APPENDIX B

Page	Line	Erratum
B-2	-14	The text after "analytical methods?" should start a new paragraph that is not part of question number 3.
B-11	24	"(Anderson and McLean)" should read "(Anderson and McLean, 1974)"
B-13	8	"extension to Eq. B.3" should read "extension to Eq. B.2"
B-14	-1	In the lower right-hand box, on the last line, the subscript "k" (lower case) should be "K" (upper case)
B-15	13	"sampling areas" should read "(sampling areas)"
B-16	5	"standard normal variable" should read "standard normal random variable"
B-20		Table B-4--LCICs are mislabeled. Labels should be: 1,2 Dichlorobenzene (1) 1,2,4 Trichlorobenzene (2) 1,2,3,4 Tetrachlorobenzene (3) Chloronaphthalene (4) alpha-BHC (5)

delta-BHC (6)
beta-BHC (7)
gamma-BHC (8)

APPENDIX F

In Figure F-1, "Blank QC" should be "Blind QC," and in Figure F-3, abbreviations "EMDC" should be "EMPC," and "Performance Handling Blank" should be "Preparation Handling Blank."

APPENDIX K

Tables K-1, K-2, and K-4 to K-14 are missing some or all of the superscripts in the title that indicate the relevant footnotes.

Table K-12 is a duplicate of Table K-11 in Volume III.

WDR355/061

ERRATA

Table 6-5
NUMBER OF FIELD QC SAMPLES RECEIVED AND ANALYZED BY LABORATORY

Analytical Laboratory[a]	Field QC Samples Received				Field QC Samples Analyzed			
	FHB	Split[h]	PHB	SSB	FHB	Split	PHB[f]	SSB[f]
1	14	22	8	19	14+3[d]	22+1[g]	--	--
2	12	17	7	18	12	17	--	--
3	11	14	10	19	11	14	--	--
4	12	11[b]	9	21	0	0	--	--
6	11	9	6	18	11	9	--	--
7	10	4	7	17	10	4	--	--
8	6	6	9	18	6	6	--	--
Totals	76	83	56[c]	130	67[e]	73[i]	--	--

FHB = Field handling blank
PHB = Preparation handling blank
SSB = Shipping and storage blank

[a] Laboratory 5 was not selected for study participation.

[b] One split was not sent to Laboratory 4.

[c] A total of 57 PHBs were used; however, one was unextrudable.

[d] Three of Laboratory 4's FHBs were analyzed by Laboratory 1.

[e] Nine FHBs were not analyzed by Laboratory 4.

[f] PHBs and SSBs were stored but not analyzed.

[g] A field spLit extracted by Laboratory 4 was analysed by Laboratory 1.

[h] A total of 83 pairs of splits were sent for analysis. One-half of each split was treated as a field sample and used in the statistical analysis. The other half is represented in this table.

[i] Valid results were obtained for both halves of 64 pairs of splits.

WDR355/061

VOLUME III
SOIL ASSESSMENT--INDICATOR CHEMICALS

ERRATA

Below is a list of errata for this report. Some of these are straightforward typographical errors, but others involve a change in content (Note--negative line numbers indicate number of lines from the bottom of the page.)

SECTIONS 1-6

Page	Line	Erratum
1-2	2	"The EDA comparison areas" should read "The EDA sampling areas"
1-3	1	"A total of 5320" should read "A total of 5329."
4-5	3	The random selection of sampling sites was done at the neighborhood level in the EDA, not at the sampling area level, as implied.
6-2		See attached Table 6-5, which shows the corrections.
6-45	3	The superscripts "a,b,c" should read "a,b,c,d"
6-48	3	The superscripts "a,b" should read "a,b,c"

APPENDIX A

There is a statement on page A-6, line 9, that ties the habitability decision to the "minimum unacceptable difference." It should be emphasized that the "delta" of one order of magnitude that was used in the design of the study (performed by CH2M HILL) is in no way related to any suggested rule for a habitability decision (which will be made by the Commissioner of Health for the State of New York.

Other Appendix A errata are as follows:

VOLUME III

Soil Assessment--
Indicator Chemicals

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New York, New York 10278

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Reston, Virginia 22090

Under Contract No. 68-01-7251

May 1988

ATTENTION

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Various agency personnel also made the following contributions:

- EPA Region II--direction of the overall study
- EPA Environmental Monitoring Systems Laboratory in Las Vegas and its contractor, Lockheed Engineering and Management Services Company--assistance with revision of analytical method; technical audits; review of analytical data; quality assurance oversight
- EPA National Enforcement Investigation Center, and its subcontractor, TechLaw, Inc.--evidentiary audits of the sample collection, preparation, and analysis programs
- DHHS/CDC--assistance with revision of the analytical method and review of statistical design and analysis
- NYSDEC--liaison with the public throughout the study
- NYSDOH--acquisition of homeowner permission to collect samples and distribution of analytical results to homeowners

CH2M HILL served as prime contractor and, under the direction of EPA Region II, managed the overall study. The participation of the following organizations is gratefully acknowledged:

- Aquatec, Clayton Environmental Consultants, Environmental Monitoring Systems, NUS Corporation, and Versar--sample analysis

- Black & Veatch--sample collection and preparation for shipment

- Cambridge Analytical Associates--assistance with revision of analytical method; sample analysis and laboratory management support; assistance with statistical design and analysis; and review and evaluation of analytical data

- DPL & Associates, Analytical Sciences, Inc., and Princeton University--assistance with statistical design and analysis

- Ecology and Environment--preparation of field equipment; logistical support; sample collection

- Horizon Systems Corporation--automated systems support; development, installation, and maintenance of software systems

- Wen Laboratory Associates--assistance in revising the analytical method; assistance in managing the laboratory team throughout the analytical phase; and review and evaluation of analytical data

LIST OF ACRONYMS AND ABBREVIATIONS

BQC	Blind quality control
CDC	Centers for Disease Control
DHHS	U.S. Department of Health and Human Services
EDA	Emergency Declaration Area
FHB	Field handling blank
EPA	U.S. Environmental Protection Agency
EMLS-LV	U.S. EPA Environmental Monitoring Systems Laboratory in Las Vegas
GC/MS	Gas chromatograph/mass spectrometer
LCIC	Love Canal Indicator Chemical
LEMSCo	Lockheed Engineering and Management Services Company
MHB	Method/holding blank
MS/MSD	Matrix spike/matrix spike duplicate
NEIC	U.S. EPA National Enforcement Investigation Center
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OTA	U.S. Congressional Office of Technology Assessment
ppb	Parts per billion
PHB	Preparation handling blank
QAPP	Quality Assurance Project Plan
QA	Quality assurance
QC	Quality control
SAS	Statistical Analysis System

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

SIM	Selected ion monitoring
SSB	Shipping and storage blank
TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
TRC	Technical Review Committee

1.0 SUMMARY

The *Love Canal Emergency Declaration Area; Proposed Habitability Criteria* document (NYSDOH and DHHS/CDC, 1986) calls for the performance of three environmental studies. The findings of one of these studies, the soil assessment for indicator chemicals, are reported here. The findings of the air assessment for indicator chemicals and the soil assessment for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) are documented in separate reports. Other reports in this series describe the decision-making process during the development of the habitability study and the subsequent peer review of its three environmental assessments.

The purpose of this study was to provide the Commissioner of Health for the State of New York with information for use in making a decision on the habitability of the Emergency Declaration Area (EDA). As directed by the Technical Review Committee (TRC), which oversees the habitability study, the purpose of this assessment is to present data and is specifically not to develop conclusions or interpretations of the data.

As called for in the habitability criteria, the specific goal of this assessment was to compare the concentrations of Love Canal Indicator Chemicals (LCICs) in the soils of the 13 EDA neighborhoods to the concentrations of those chemicals in the soils of three selected comparison areas. The comparison areas were western New York communities that are similar to the EDA but are not close to a known chemical landfill. The original LCICs called for in the habitability criteria were four specific chlorinated benzene compounds, two BHC isomers, total BHC, and 2-chloronaphthalene. Chlorobenzene was dropped from the soil assessment based on poor performance in volatile analysis during a pilot study. The three other chlorinated benzene compounds were retained. Improvements to the semivolatile analytical method allowed two additional BHC isomers to be added which provided a more accurate measure of total BHC. The final list of LCICs used for the soil assessment included 1,2-dichlorobenzene; 1,2,4-trichlorobenzene; 1,2,3,4-tetrachlorobenzene; 2-chloronaphthalene; alpha-BHC; delta-BHC; beta-BHC; and gamma-BHC. (Use of the four BHC isomers replaced the need for total BHC.)

The study was designed to perform a statistical comparison between EDA sampling areas and comparison areas. The EDA comparison areas were formed from neighborhoods on the basis of recommendations from a peer review of a previously conducted pilot study. The comparison method assumes that data collected from the comparison areas correspond to "normal" or habitable conditions, and that comparing these data to similar measurements from the EDA will indicate whether differences exist.

The analytical chemistry method used in the soil assessment for LCICs was developed over the course of the pilot study and was further modified before the soil samples were collected. The results of a previous sampling study conducted in the EDA in the summer of 1980 (U.S. EPA, 1982) indicated that a large percentage of contaminant levels were recorded as non-detects; therefore, low detection limits were needed to provide the data required for the statistical comparisons. A method utilizing a gas chromatograph/mass spectrometer (GC/MS) operating in the selected ion monitoring (SIM) mode was developed specifically for this study to provide typical operational detection limits in the 0.2- to 0.3-part-per-billion (ppb) range for all eight LCICs. The actual detection limits for a particular sample depended on the individual LCIC, sample interferences, and the GC/MS instrument. For many samples with limited interferences, LCICs were detected at levels below 0.2 ppb.

An information management system was developed to expedite the schedule of the study, minimize transcription errors, and facilitate quality assurance/quality control (QA/QC) and statistical manipulation of the analytical results.

To monitor and maintain quality in the collection, management, and use of environmental data, QA/QC was a key element in the design of the study. Thus, strict QA/QC requirements and protocols were implemented in the field sampling, chemical analysis, statistical analysis, and data management efforts.

Sample collection was conducted during October and November 1987. Actual implementation of the planned sample allocations among sampling areas, sampling crews, and laboratories proceeded with no significant deviations from the plan. A total of 879 prepared field samples were sent to seven laboratories for analysis. Seven hundred eighty-one of these samples were successfully analyzed for each of the eight LCICs, resulting in

6,248 analyses. A total of 5,320 valid analytical results (85 percent) were obtained for use in the statistical comparisons.

Specific quantitative criteria, or control limits, were set for several QC measures. Certain of these criteria were mandatory, while others were advisory only. For each such measure, a goal was established that either 90 or 100 percent of the analytical results for each LCIC should meet the criteria. These goals were achieved for all of the QC measures, with the minor exception of one type of QC sample analysis that did not meet advisory control limits. The validated results, which met mandatory control limits, were used in the statistical analysis.

A "nonparametric" statistical method (the Wilcoxon rank-sum test) was selected for assessing differences in LCIC concentrations because it required generally less restrictive assumptions than alternative methods, while maintaining high "power" or ability to detect differences between neighborhoods. This method also was well-suited to data with relatively large fractions of nondetectable values. A related test was used to conduct simultaneous (multivariate) comparisons for all LCICs.

The comparisons between LCIC concentration distributions in the EDA sampling areas and comparison areas indicated some significant differences at the 0.05 and 0.01 significance levels. (A 0.01 significance level means that there is a 1-in-100 chance that a difference as large as that observed could occur by chance alone. A 0.05 significance level corresponds to a 1-in-20 chance.) The results, as they relate to the habitability of the EDA, have not been interpreted in this report. These findings will be reviewed by a panel of scientists. In accordance with the habitability criteria document, the results will be presented to the Commissioner of Health for the State of New York for use in a determination of habitability.

2.0 INTRODUCTION

This report is Volume III of a five-volume series. Volume I provides an introduction and documentation of the decision-making during the development of the Love Canal EDA Habitability Study. For readers not familiar with the Love Canal EDA Habitability Study, it is recommended that Volume I be read before this volume. Volume II reports on the air assessment for LCICs. Volume IV presents the results of the soil assessment for 2,3,7,8-TCDD, and Volume V will summarize the subsequent peer review of Volumes II, III, and IV and the responses to that peer review.

This document summarizes the design and results of the soil assessment for LCICs. It is presented in six main sections and contains 11 appendices. This section gives an overview of the history of the site and a summary of previous environmental studies conducted in the EDA. Sections 3.0, 4.0, and 5.0 discuss the study goals, design, and methods, respectively. Section 6.0 presents the study results. The appendices contain more detailed, technical information on the study methods, results, field and laboratory audits, and analytical data validation.

2.1 BACKGROUND

A detailed history of Love Canal is presented in Volume I. This section provides a brief summary to assist the reader in understanding the overall intent of the Love Canal EDA Habitability Study and the role of the soil assessment for LCICs.

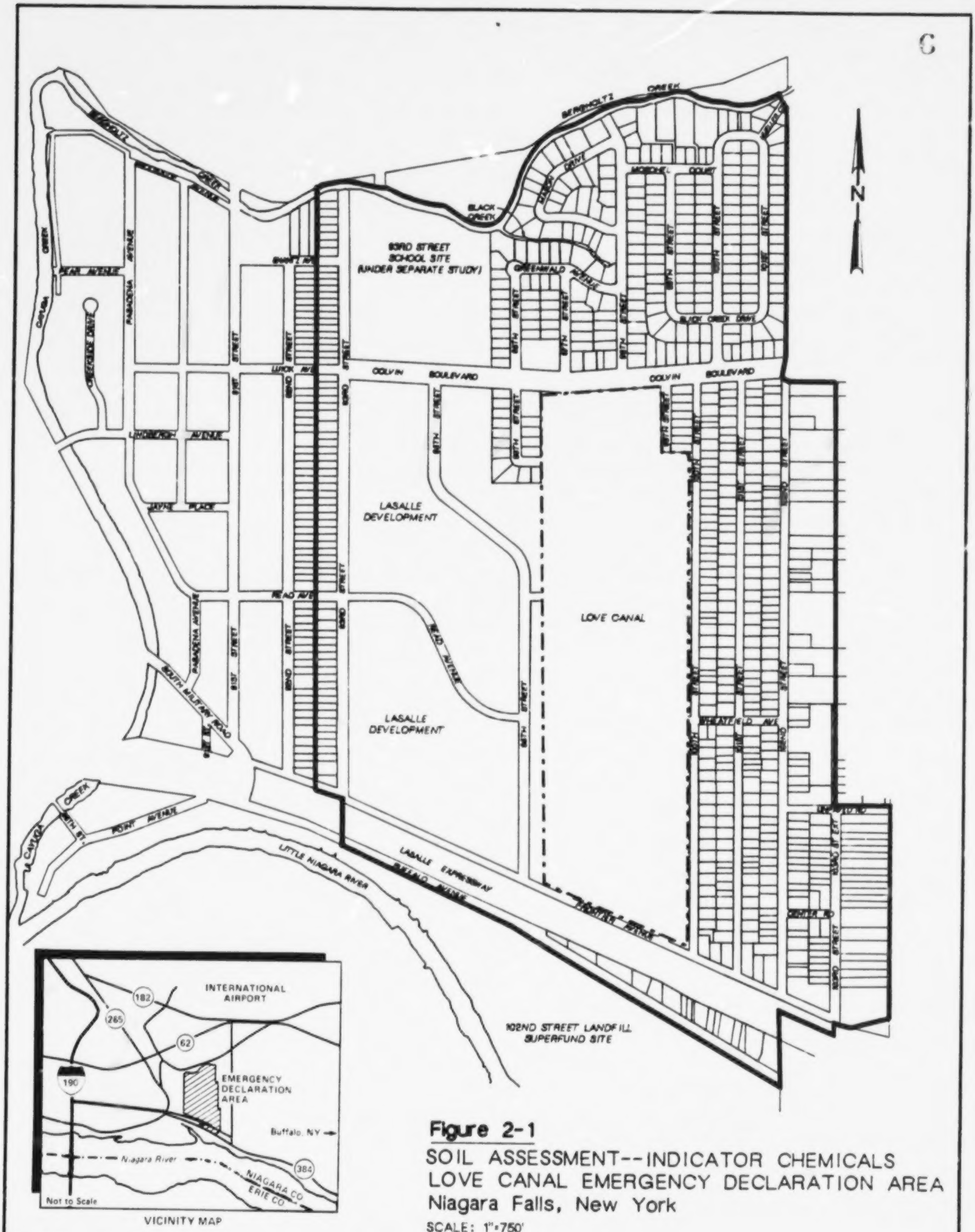
The former Love Canal landfill was a rectangular, 16-acre tract of land located in the southeastern end of the City of Niagara Falls in Niagara County on the western edge of New York State. The landfill takes its name from William T. Love, whose plan in the 1890s was to dig a canal between the upper and lower Niagara River to provide inexpensive hydroelectric power for a proposed model industrial city. The model city project and the partially dug canal were abandoned before the turn of the century. The abandoned canal was used as a chemical and municipal waste dump from 1942 to 1954. In 1954, the site was closed. Subsequently, home-building accelerated around Love Canal, and the 99th Street School was built adjacent to it. Soil from the canal was moved to the 93rd Street School site where it was used as fill. Anecdotal information indicates that fill material from the canal area may also have been moved to other locations within the EDA.

In the spring of 1978, following a series of complaints by local residents, studies were initiated to investigate the health and environmental problems at Love Canal. Under the direction of the New York State Department of Health (NYSDOH), basement sumps were sampled, and, under the direction of the U.S. EPA, air samples were taken at homes abutting the canal. Sample results revealed significant contamination, and in August 1978, the first of two states of emergency was declared by President Carter. Homes were sold on a voluntary basis and remedial efforts were under way by October 1978.

Initial remediation of Love Canal concentrated on site containment. A clay cap was installed over the canal area, and perimeter/barrier drains were installed during 1979. A leachate treatment plant was constructed during late 1979 to handle leachate from the collection system. Since that time, an extensive program for removing contaminated sediments from area sewers and creeks has been under way, along with improvements to the final cover system completed in 1984. (Volume I of this report provides additional details on Love Canal remediation efforts.)

Meanwhile, concern persisted about the habitability of the residential area surrounding Love Canal. In May 1980, President Carter issued a second emergency declaration for Love Canal establishing the EDA as shown in Figure 2-1. Eligible properties were purchased on a voluntary basis from residents by the Love Canal Area Revitalization Agency (established by the New York State Legislature).

In the summer of 1982, the EPA released a report assessing the extent of air, water, and soil contamination in the EDA. The report was intended for use as a basis for making recommendations regarding future use of the area (U.S. EPA, 1982). Subsequently, the U.S. Department of Health and Human Services (DHHS) was requested to review the EPA study and other data to determine whether the EDA was habitable. In July 1982, after considering comments by the National Bureau of Standards on the procedures used in the EPA study and after further consultation with the EPA, DHHS affirmed an earlier provisional decision that the EDA was as habitable as the areas with which it had been compared. This decision was contingent on the provision that the storm sewers and their drainage tracts be cleaned and that


C
N
BERGHOLTZ CREEK
BLACK CREEK
93RD STREET SCHOOL SITE (UNDER SEPARATE STUDY)
GREENWALD AVENUE
MOSCHEL COURT
BLACK CREEK DRIVE
99TH STREET
100TH STREET
101ST STREET
COLVIN BOULEVARD
LUDWICK AVE
LASALLE DEVELOPMENT
LOVE CANAL
READ AVE
READ AVENUE
WHEATFIELD AVE
96TH STREET
97TH STREET
98TH STREET
93RD STREET
92ND STREET
91ST STREET
PASADENA AVENUE
LINDBERGH AVENUE
JAYNE PLACE
PEAR AVENUE
CREEKSIDE DRIVE
CAYUGA CREEK
SOUTH MILITARY ROAD
POINT AVENUE
LA CAYUGA
88TH ST.
LASALLE EXPRESSWAY
BUFFALO AVENUE
FRONTIER AVENUE
LITTLE NIAGARA RIVER
CENTER RD
102ND STREET
102ND STREET LANDFILL SUPERFUND SITE
INTERNATIONAL AIRPORT
182
265
62
190
EMERGENCY DECLARATION AREA
Buffalo, NY
Niagara River
384
NIAGARA CO
ERIE CO
Not to Scale

VICINITY MAP

Figure 2-1

SOIL ASSESSMENT--INDICATOR CHEMICALS
LOVE CANAL EMERGENCY DECLARATION AREA
Niagara Falls, New York

SCALE: 1"=750'

LEGEND

━━ EMERGENCY DECLARATION AREA (EDA) BOUNDARY

SOURCE:
EDA BOUNDARIES TAKEN FROM NEW YORK STATE
REAL PROPERTY TAX LAW ARTICLE 17, SECTION 1702

the remedial actions "...be re-evaluated to guarantee permanent containment of chemicals in the dump" (NYSDOH and DHHS/CDC, 1986).

In December 1982, the U.S. Congressional Office of Technology Assessment (OTA) was requested to examine the technical basis for and validity of the habitability decision for the EDA. Questions arose pertaining to the quality and the limits of detection of some of the previously collected environmental data. In June 1983, the OTA reported that, with the information available, it was impossible to conclude whether or not unsafe levels of toxic contamination existed in the EDA and that the analysis of available data did not support the DHHS decision that the EDA was as habitable as the areas with which it had been compared (OTA, 1983).

In August 1983, in response to the OTA report, the EPA established a TRC composed of representatives from the EPA, NYSDOH, DHHS/Centers for Disease Control (CDC), and the New York State Department of Environmental Conservation (NYSDEC) to coordinate and oversee the habitability study and remedial program at Love Canal. The member agencies of the TRC asked NYSDOH and DHHS/CDC to develop criteria that would be considered by the New York State Commissioner of Health in deciding whether or not the EDA is habitable. The habitability criteria were developed by NYSDOH and DHHS/CDC with extensive input from the public and an advisory panel of scientists. The habitability criteria underwent peer review (Life Systems, 1986) and in 1986, the *Love Canal Emergency Declaration Area; Proposed Habitability Criteria* document (NYSDOH and DHHS/CDC, 1986), which reflects the concerns of the peer review, was issued.

2.2 HABITABILITY CRITERIA

The habitability criteria stipulate that for chemicals identified in environmental media to which current and potential residents may have significant exposure, relevant Federal and New York State standards, criteria, and guidelines will be used to assess the habitability of the EDA. The only known applicable guideline, however, is the CDC level of concern of 1.0 ppb for 2,3,7,8-TCDD in residential surface soil. Thus, the habitability criteria require environmental sampling of residential surface soil in the EDA for 2,3,7,8-TCDD.

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Because no known standards, criteria, or guidelines are available for the other chemicals known or suspected to have been deposited in Love Canal, the criteria call for a comparison of the results of environmental sampling in neighborhoods (soil) and residences (air) in the EDA with the results of sampling in similar inhabited communities in western New York. (As stated earlier, the results of the air assessment were presented in Volume II of this series.)

The habitability criteria require that the comparisons be made on the concentrations of LCICs in soil in each neighborhood in the EDA and in the comparison areas. Eight LCICs were initially selected for the soil assessment:

- Total BHC
- Beta BHC
- Gamma BHC
- Chlorobenzene
- 1,2-dichlorobenzene
- 1,2,4-trichlorobenzene
- 1,2,3,4-tetrachlorobenzene
- 2-chloronaphthalene

These chemicals were selected to represent a larger number of chemicals potentially originating from Love Canal and to assess the potential chemical contamination of the EDA by Love Canal (NYSDOH and DHHS/CDC, 1986, Appendix 9). (The list of LCICs used in the soil assessment was later revised, as discussed in Sections 2.3 and 5.2. of this report.)

The comparison method assumes that data collected from simiiar western New York communities not near a chemical landfill will correspond to "normal" or habitable conditions and that comparing these data with similar measurements in the EDA will provide an indication of whether EDA neighborhoods are different from the selected comparison areas. The habitability criteria document states that one of the conditions for a neighborhood in the EDA to be considered habitable is the following:

> ...the chosen aggregate values (e.g., mean, median, percentiles, etc.) of each non-TCDD LCIC evaluated both individually (univariate) and collectively (multivariate) are not significantly different than the values from the comparison areas...(NYSDOH and DHHS/CDC, 1986)

Comparison areas were selected based on the following general characteristics. The comparison areas should:

- Be inhabited residential census tracts in western New York State
- Contain soil types and hydrogeological conditions similar to those found in the EDA
- Have borders located as far from known chemical landfills as possible, but no less than one-half mile

The comparison area initially selected was an aggregate (combination) of neighborhoods in Tonawanda and Cheektowaga, New York. (Additional comparison areas were selected after peer review of the pilot study, discussed in Section 2.5.)

Neighborhoods within the EDA were delineated during the development of the habitability criteria to facilitate a habitability decision on a neighborhood basis. The EDA neighborhoods are shown in Figure 2-2.

2.3 PILOT STUDY

In preparation for the soil assessment for LCICs, a pilot study was conducted to demonstrate the feasibility of implementing the habitability criteria as proposed (CH2M HILL, 1987c). Specific objectives were to:

- Determine if specially developed techniques for soil sample collection and preparation were suitable for use in the soil assessment for LCICs
- Develop and evaluate new analytical procedures for measuring volatile and semivolatile LCICs in soil at low-level (i.e., 1 to 10 ppb) concentrations
- Provide information on the sources and magnitude of intralaboratory and interlaboratory variability in the analytical data
- Develop methods for estimating LCIC detection limits

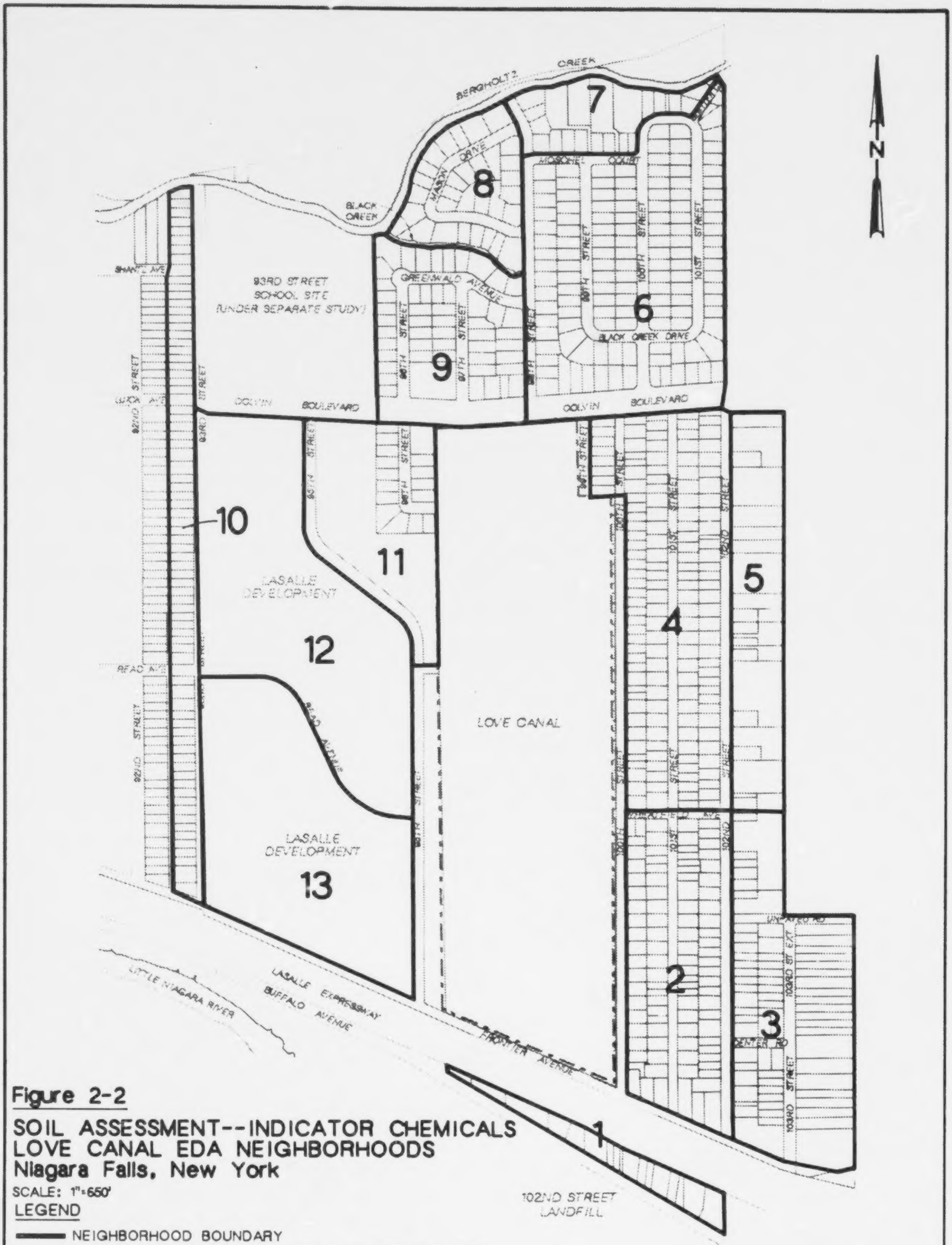
BERGHOLTZ CREEK
7
MOSONEL COURT
8
MASON DRIVE
BLACK CREEK
93RD STREET SCHOOL SITE (UNDER SEPARATE STUDY)
GREENWALD AVENUE
96TH STREET
97TH STREET
9
98TH STREET
99TH STREET
100TH STREET
101ST STREET
6
BLACK CREEK DRIVE
COLVIN BOULEVARD
SHARTL AVE
92ND STREET
93RD STREET
LUDA AVE
10
95TH STREET
96TH STREET
11
LASALLE DEVELOPMENT
12
READ AVE
READ AVENUE
LASALLE DEVELOPMENT
13
LOVE CANAL
99TH STREET
100TH STREET
101ST STREET
102ND STREET
4
5
CHEEKTOWAGA AVE
2
3
UNPAVED RD
103RD ST EXT
CENTER RD
103RD STREET
LITTLE NIAGARA RIVER
LASALLE EXPRESSWAY
BUFFALO AVENUE
FRONTIER AVENUE
1
102ND STREET LANDFILL
N

Figure 2-2

SOIL ASSESSMENT--INDICATOR CHEMICALS
LOVE CANAL EDA NEIGHBORHOODS
Niagara Falls, New York

SCALE: 1"=650'

LEGEND

— NEIGHBORHOOD BOUNDARY
— · — FENCE LINE AROUND LOVE CANAL REMEDIATION SITE

SOURCE: NEIGHBORHOOD BOUNDARIES ADAPTED FROM THE PROPOSED HABITABILITY CRITERIA DOCUMENT (NYSDOH AND DHHS/CDC, 1986).

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- Provide data of known and defensible quality to estimate the statistical distribution of LCIC concentration data in the EDA and comparison areas

- Provide a basis for determining the number of samples that need to be taken to produce statistically valid results in the soil assessment for LCICs

A total of 90 soil samples were collected in the EDA, Cheektowaga, and Tonawanda during July 1986. Samples were collected using a Shelby tube that was hydraulically pushed into the soil by a Porta Sampler. This provided an undisturbed soil sample to a depth of about 1 foot. Samples were analyzed using a GC/MS operating in the SIM mode. The average detection limits for each of the eight LCICs were estimated to range from 0.5 to 2.5 ppb during the pilot study. The detection limits provided by the analytical method were significantly lower than those provided in the 1980 EPA study, generally by a factor of more than 100.

The following are the conclusions and recommendations of the pilot study that were incorporated in the soil assessment for LCICs.

- The sample collection method worked well in obtaining a relatively undisturbed soil sample. However, the full 13-inch depth of the sample was difficult to impossible to obtain in areas of fill and rubble. It was recommended that the sample depth requirement be reduced to generate the minimum amount of soil required for the analytical method.

- The specially developed analytical method was generally capable of reliably identifying and quantifying LCIC concentrations at the 1-ppb level with the exception of the BHCs, which had higher detection limits. Some low-level contamination of laboratory blank samples was encountered. The analytical method was revised to reduce the likelihood of laboratory contamination. Variability in the results suggested that the semivolatile sample extraction procedures required modifications and that the laboratories should be trained to obtain a more uniform application of the extraction procedure.

- 1,2-dichlorobenzene was analyzed by both volatile and semivolatile analysis and exhibited poor chromatographic performance in the volatile analysis. Higher concentrations were observed in the semivolatile analysis. Based on these results, it was recommended that only the semivolatile analysis be retained for the analytical process and that chlorobenzene be deleted from the list of indicator chemicals for the soil assessment, because chlorobenzene was the only LCIC besides 1,2-dichlorobenzene that was analyzed by the volatile analysis and it was not detected in any of the samples. (Chlorobenzene would still be in the habitability study as an indicator chemical for the air assessment.)

- Interlaboratory variability was found to be significant compared to between-sampling-area variability. It was recommended that sample allocation among the laboratories be designed to minimize the effect of interlaboratory variability on the results of the comparison in this study.

- An estimator of the method detection limits was developed. The estimator was complicated by the sample-specific interferences and the qualitative nature of the analyte identification criteria.

- No clear evidence of patterns or areas of localized contamination within neighborhoods existed. This indicated that a randomized method of selecting sample sites would be appropriate.

- Samples should be allocated among neighborhoods in proportion to the area of the neighborhood in order to preserve a more or less uniform spatial density of the sampling points.

- Based on the pilot study data, a minimum number of samples per neighborhood was set to preserve the power (see Appendix A) of detecting differences between small neighborhoods and comparison areas. (Neighborhoods were later combined to form sampling areas based on peer review recommendations as discussed in Section 2.5.)

Further discussion of the pilot study findings can be found in the pilot study report.

2.4 NYSDOH SOIL STUDY

A higher percentage of detects of 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene was found in the EDA than in the comparison areas during the pilot study. There was reason to believe that the source of trichlorobenzene and tetrachlorobenzene might be other than Love Canal. In an attempt to determine whether the 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene soil contamination was widespread in the Niagara Falls area or restricted to the EDA and to identify the source of contamination, NYSDOH conducted a sampling program during November 1986. Soil samples were collected in the EDA, Cheektowaga, and three new areas in or near the City of Niagara Falls. The areas sampled were selected to account for significant differences among areas that might be the result of an upwind industrial source, the City of Niagara Falls water supply (used for watering lawns, gardens, etc.), or other unknown sources.

The results of this study indicated that similar concentrations of 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene occurred throughout the areas sampled in the greater Niagara Falls area and were not elevated specifically within the EDA. However, the source of the contamination was not conclusively identified.

Using a different analytical method, the NYSDOH study had attained detection limits of around 0.2 ppb for 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene and found significant numbers of samples with concentrations above this level but less than 1 ppb. Thus, NYSDOH requested that the analytical method used in the pilot study be further modified for this soil assessment to provide detection limits as low as possible with a target of 0.1 to 0.2 ppb for the majority of the LCICs.

2.5 PEER REVIEW

A scientific peer review of the pilot study was conducted in March 1987 (Life Systems, 1987). The following are the recommendations of the peer reviewers that were incorporated into the study.

- Based on the results of the independent study by NYSDOH, additional comparison areas should be added in Niagara Falls.

- Sample depth should be at least 7 and not more than 12 inches, depending on the ability to collect the samples. Further details on the recommended sampling protocol can be found in the document summarizing responses to the peer review of the pilot study (CH2M HILL, 1987d).

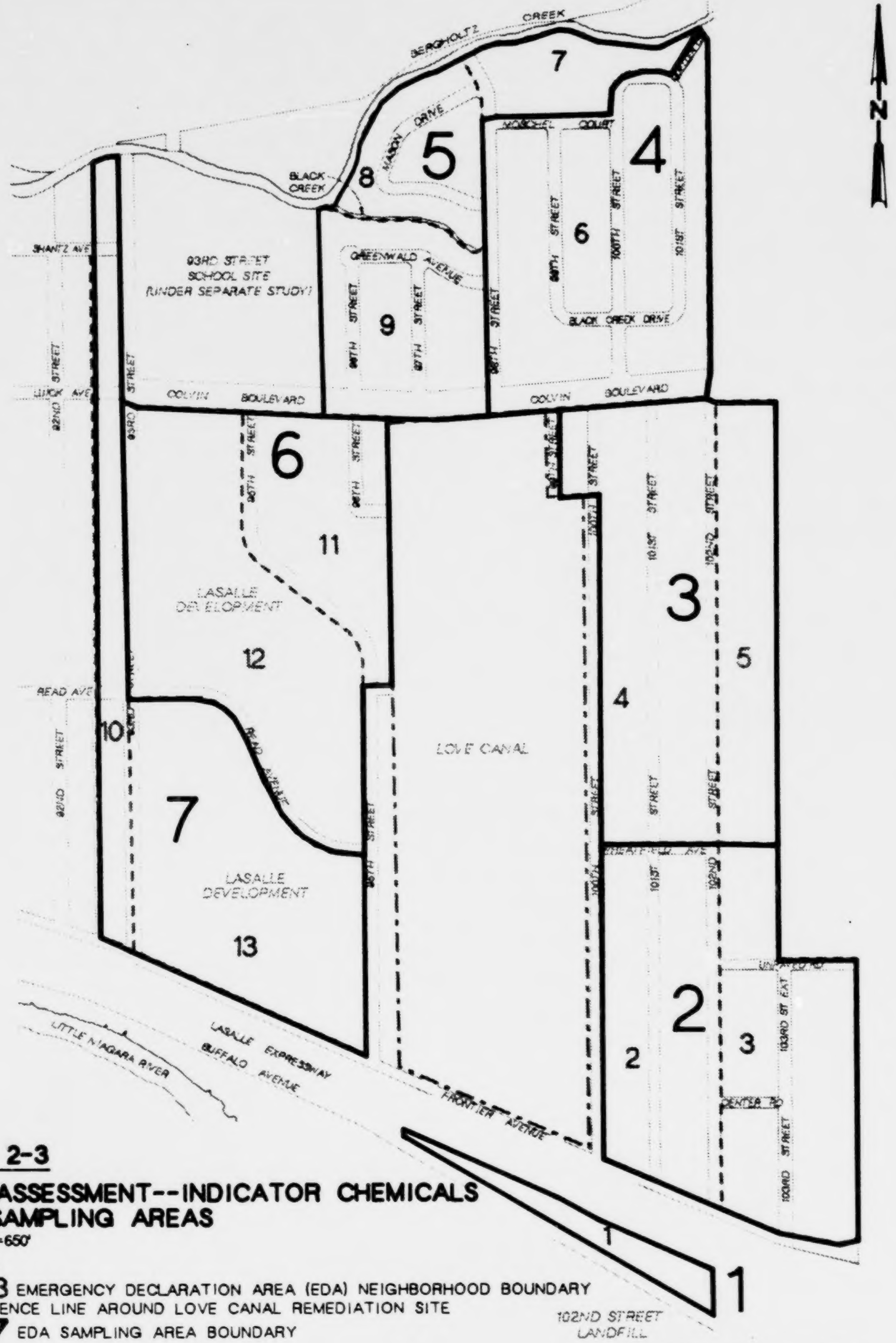
- Only the semivolatile analysis should be retained, thus eliminating chlorobenzene as an LCIC for the soil assessment.

- Specified EDA neighborhoods should be combined to form seven sampling areas for purposes of sample allocation and statistical comparisons. (This was recommended to make the sampling density similar for each area compared and reduce the number of comparisons.) The neighborhoods should be combined as shown in Figure 2-3. Neighborhood 1 should not be combined, even though it is small relative to the other neighborhoods, because of the high number of LCIC detects in that area. This neighborhood may be more densely sampled than other neighborhoods in the EDA.

- The random sampling method should be modified by using a grid to create a more uniform spatial distribution of samples.

In response to the peer reviewers' comments, and based on the pilot study report, the TRC selected two additional comparison areas. Specifically, portions of Census Tracts 221 and 225 in the City of Niagara Falls were selected based on the habitability criteria guidelines. The relative locations of the comparison areas and the EDA are shown in Figure 2-4.

Sections 3.0, 4.0, and 5.0 describe how these peer review recommendations were incorporated into the study goals, design, and methods.


N
BERGHOLTZ CREEK
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MASON DRIVE
MOSCHEL COURT
GREENWALD AVENUE
BLACK CREEK DRIVE
99TH STREET
100TH STREET
101ST STREET
93RD STREET SCHOOL SITE (UNDER SEPARATE STUDY)
SHANTZ AVE
LUICK AVE
READ AVE
92ND STREET
93RD STREET
96TH STREET
97TH STREET
98TH STREET
COLVIN BOULEVARD
6
11
12
LASALLE DEVELOPMENT
10
7
13
READ AVENUE
LOVE CANAL
3
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102ND STREET
103RD ST EXT
103RD STREET
WHEATFIELD AVE
UNIVERSITY RD
CENTER RD
LASALLE EXPRESSWAY
BUFFALO AVENUE
LITTLE NIAGARA RIVER
FRONTIER AVENUE
1
1
102ND STREET LANDFILL

Figure 2-3

SOIL ASSESSMENT--INDICATOR CHEMICALS
EDA SAMPLING AREAS
SCALE: 1"=650'

LEGEND

- - - 13 EMERGENCY DECLARATION AREA (EDA) NEIGHBORHOOD BOUNDARY
- · - FENCE LINE AROUND LOVE CANAL REMEDIATION SITE
— 7 EDA SAMPLING AREA BOUNDARY

SOURCE: NEIGHBORHOOD BOUNDARIES ADOPTED FROM THE PROPOSED HABITABILITY CRITERIA DOCUMENT (NYSDOH AND DHHS/CDC, 1986)

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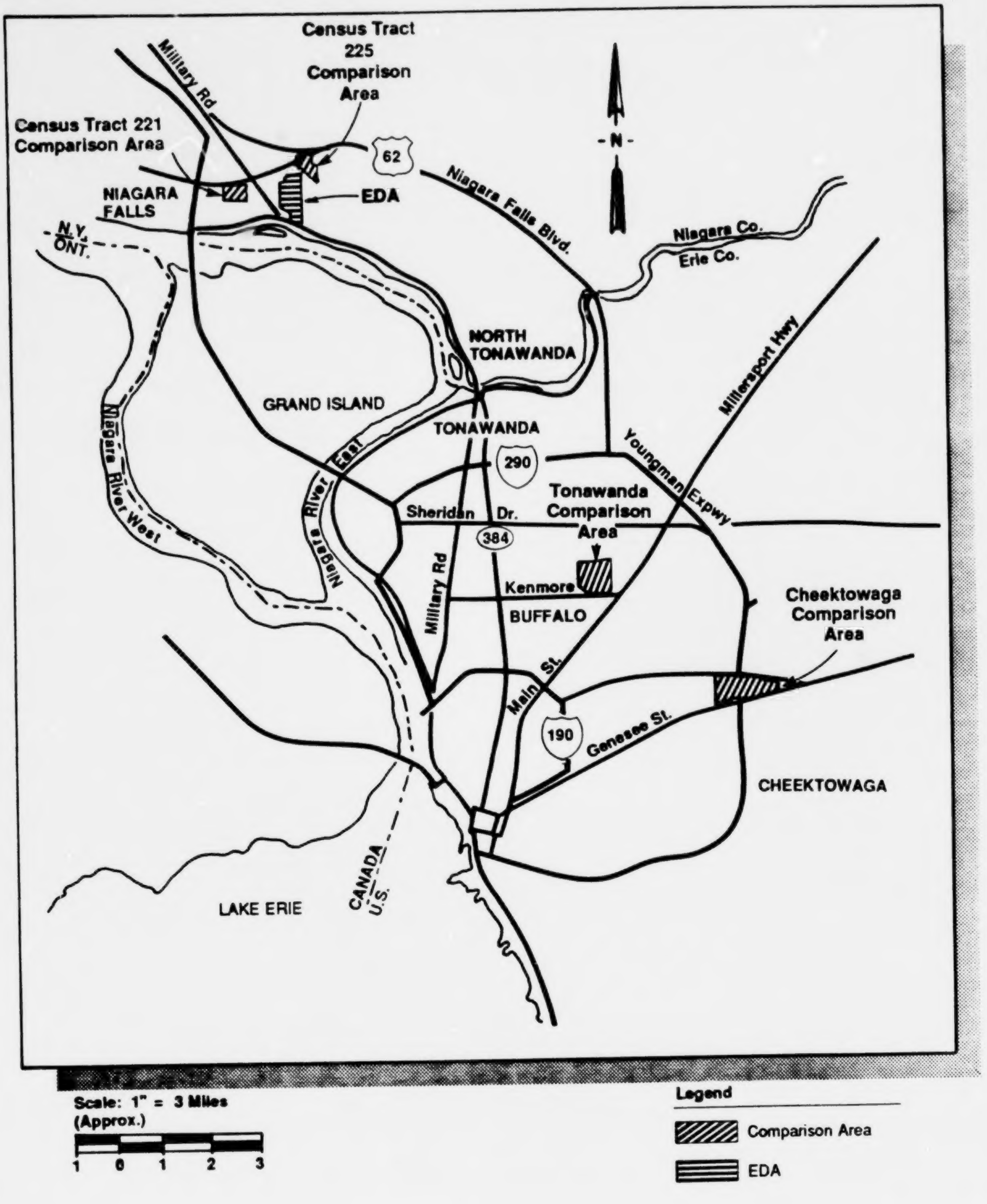
Census Tract 225 Comparison Area
Census Tract 221 Comparison Area
Military Rd
62
Niagara Falls Blvd.
NIAGARA FALLS
EDA
- N -
N.Y.
ONT.
Niagara Co.
Erie Co.
NORTH TONAWANDA
GRAND ISLAND
TONAWANDA
Millersport Hwy
Youngman Expwy
290
Niagara River West
Niagara River East
Sheridan Dr.
384
Tonawanda Comparison Area
Military Rd
Kenmore
BUFFALO
Cheektowaga Comparison Area
Main St.
190
Genesee St.
CHEEKTOWAGA
CANADA
U.S.
LAKE ERIE
Scale: 1" = 3 Miles (Approx.)
1 0 1 2 3
Legend
Comparison Area
EDA

Figure 2-4
SOIL ASSESSMENT--INDICATOR CHEMICALS
LOCATION OF EDA AND COMPARISON AREAS
IN NEW YORK STATE

3.0 GOALS

The purpose of this study, in accordance with the proposed habitability criteria (NYSDOH and DHHS/CDC, 1986), was to provide the New York State Commissioner of Health with information for use in making a decision on the habitability of the EDA. As called for in the habitability criteria document, the specific goal of this assessment was to provide a statistical comparison of the concentrations of LCICs in the EDA neighborhoods with concentrations in each of the selected comparison areas on a univariate (individual) and multivariate (collective) LCIC basis.

To conduct the comparisons and to provide data of known and defensible quality, the following specific objectives were developed:

1. Meet the overall QA/QC objectives detailed in the sample collection and preparation Quality Assurance Project Plan (QAPP [CH2M HILL, 1987a]) and in the sample analysis QAPP (CH2M HILL, 1987b).

2. Use a sufficient number of samples so that the statistical comparisons can achieve a 90 percent probability of being able to detect, with 95 percent confidence, an order-of-magnitude difference in median concentration of LCICs between EDA sampling areas and the comparison areas. The statistical considerations used to develop this objective are discussed in Appendix 10 of the habitability criteria document.

3. Achieve the lowest technically feasible analytical detection limits.

4.0 DESIGN

The overall design of the soil assessment for LCICs was based on the proposed habitability criteria (NYSDOH and DHHS/CDC, 1986), the results of the pilot study (CH2M HILL, 1987c), and TRC directives. This design involves three main elements: project organization, study design, and QA/QC design. Each of these three elements is discussed below.

4.1 PROJECT ORGANIZATION

Project organization and responsibilities of key personnel are detailed in the soil sample collection and preparation QAPP (CH2M HILL, 1987a) and the soil sample analysis QAPP (CH2M HILL, 1987b). Organizational responsibilities are illustrated in Figure 4-1.

EPA Region II directed the project and provided technical guidance as a member of the TRC. Technical guidance was also provided by the other members of the TRC: DHHS/CDC, NYSDEC, and NYSDOH. The data that were collected and analyzed were subjected to independent review by Environmental Monitoring Systems Laboratory in Las Vegas/Lockheed Engineering and Management Services Company (EMSL-LV/LEMSCo.) CH2M HILL served as the prime contractor.

Individual teams were organized to execute the five major components of the project, as shown on Figure 4-1: sample collection, sample preparation, sample analysis, real-time laboratory QC, and statistical design and analysis. Additional teams provided automated systems support and laboratory-related assistance throughout the project.

4.2 STUDY DESIGN

The overall design addressed all phases of the study, including sampling design, analytical design, and data base development.

The statistical design affects most aspects of the data collection and analysis and accordingly is discussed first here. Although the technical detail

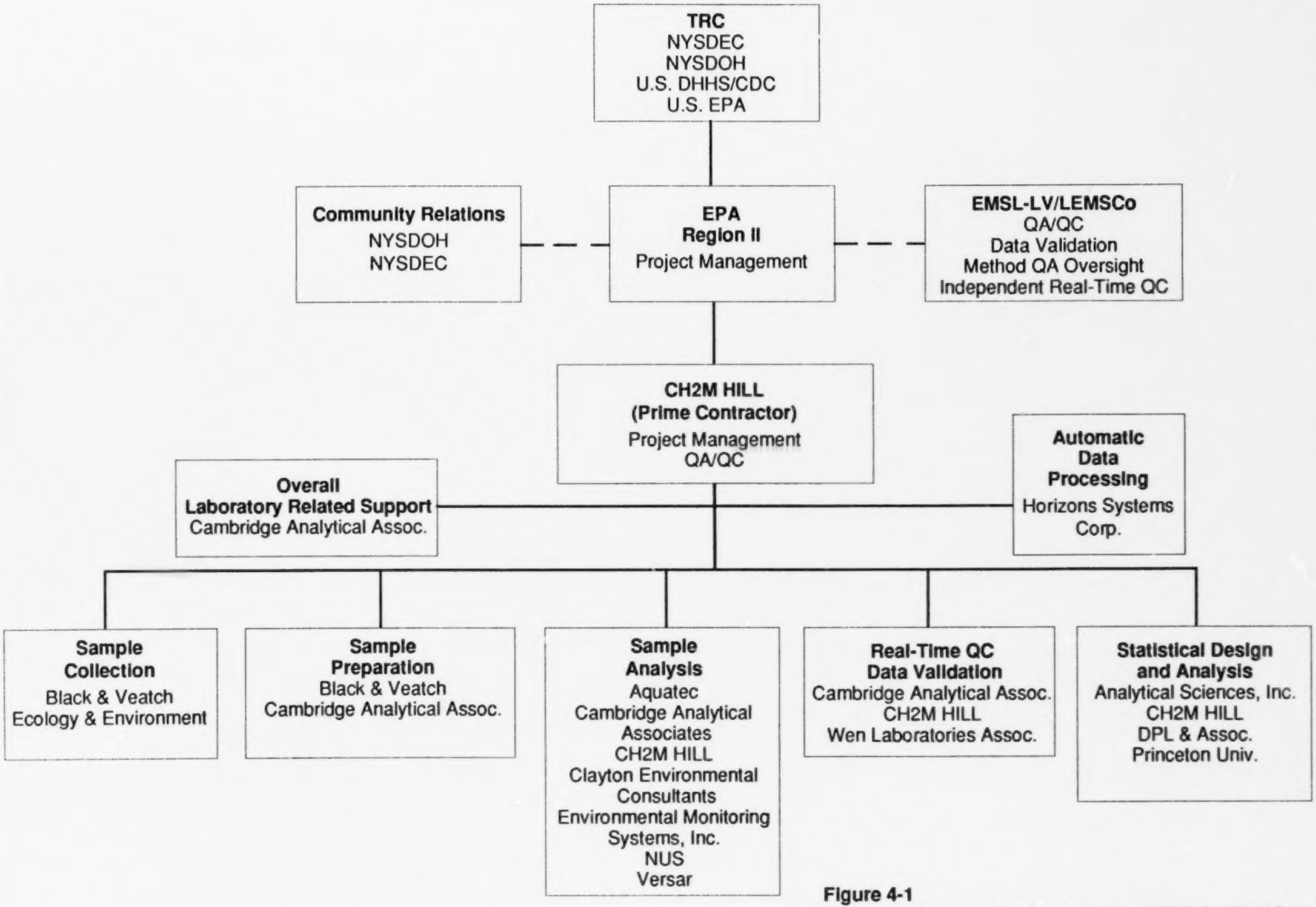
TRC
NYSDEC
NYSDOH
U.S. DHHS/CDC
U.S. EPA
Community Relations
NYSDOH
NYSDEC
EPA
Region II
Project Management
EMSL-LV/LEMSCo
QA/QC
Data Validation
Method QA Oversight
Independent Real-Time QC
CH2M HILL
(Prime Contractor)
Project Management
QA/QC
Overall
Laboratory Related Support
Cambridge Analytical Assoc.
Automatic
Data
Processing
Horizons Systems
Corp.
Sample
Collection
Black & Veatch
Ecology & Environment
Sample
Preparation
Black & Veatch
Cambridge Analytical Assoc.
Sample
Analysis
Aquatec
Cambridge Analytical
Associates
CH2M HILL
Clayton Environmental
Consultants
Environmental Monitoring
Systems, Inc.
NUS
Versar
Real-Time QC
Data Validation
Cambridge Analytical Assoc.
CH2M HILL
Wen Laboratories Assoc.
Statistical Design
and Analysis
Analytical Sciences, Inc.
CH2M HILL
DPL & Assoc.
Princeton Univ.

Figure 4-1
SOIL ASSESSMENT - - INDICATOR CHEMICALS
PROJECT ORGANIZATION

included in this section is purposely kept to a minimum, the reader unfamiliar with basic statistical principles may find it helpful to read Appendix A, Statistical Concepts, as a supplement both to this section and to Section 5.5, Statistical Analysis. Appendix B provides an in-depth and more technically oriented discussion of the statistical design and methods used in this study.

The statistical design of any sampling program should be tied to the characteristics of the data that are to be analyzed. In this study, the data are the soil concentrations at specific locations in the EDA and comparison areas. Theoretically, the concentration in any sample can be considered to reflect four effects, or factors:

1. Regional characteristics common to all EDA sampling areas and comparison areas (for instance, regional geologic characteristics)

2. Local effects specific to the given EDA sampling or comparison area

3. Laboratory characteristics specific to the laboratory at which the chemical analysis was conducted

4. All other effects, including spatial variations within a sampling area, intra-laboratory measurement variability, and field data collection and sample handling variability

The primary motivation in the sampling design was to isolate and measure the effects of factor 2, differences between the EDA sampling areas and the comparison areas. In this respect, factor 1 is irrelevant, because it affects all samples, regardless of area. Factors 3 and 4 can be considered to represent external effects that must be carefully controlled to avoid biasing or invalidating the results. For instance, assume that all samples from Comparison Area 1 were collected by sampling crew A, and all samples from EDA Sampling Area 2 were collected by sampling crew B. Then if samples collected by sampling crew A tended to have consistently higher concentrations than those collected by sampling crew B (for instance, because of improper sample handling, resulting in contamination of the samples), a conclusion that soil concentrations in Comparison Area 1 and EDA Sampling Area 1 were statistically different might well be invalid.

Randomization is one way to prevent external effects from biasing results. The idea behind randomization is that if an external effect is properly distributed over the known factors, then statistically it will affect the known factors equally and will not bias the results. However, randomizing the unwanted external effects instead of estimating them explicitly may obscure some of the true differences, if any, between EDA sampling areas and comparison areas by increasing the variability of the data distribution. Increased variability makes a larger number of samples necessary to detect differences between areas. For this reason, it is desirable to minimize the external effects as much as possible through rigorous oversight and QA/QC procedures.

Randomization was insufficient to control for the effect of inter-laboratory variability, which was found in the pilot study to be larger than other external effects. Accordingly, "blocking," another statistical procedure to control external effects, also was used. To block inter-laboratory effects, all statistics about an area are accumulated using only data analyzed by a given laboratory. Then these statistics (one for each laboratory) are combined to form a grand statistic that is used to perform the comparisons.

In summary, the statistical design that was adopted treated external effects as follows:

- The effects of sampling and laboratory analysis protocol, including the assignment of sampling teams to neighborhoods, the assignment of samples collected by each team to laboratories, the order of sample collection, and the order of sample analysis by each laboratory, were randomized. In addition, the QA/QC protocol acted to keep the magnitude of these external factors to a minimum.

- The effects of inter-laboratory variations were accounted for by blocking.

Minimum sample sizes for each sampling area were determined from simulations of the power of the proposed statistical tests, using the distribution from the pilot study results and pilot study analytical detection limits. The minimum sample size per sampling area was set at 75, with the exception of EDA Sampling Area 1, for which the minimum sample size was 50. (Sampling Area 1 is significantly smaller than the other sampling areas; thus, 50 samples for this sampling area represented a compromise between maintaining approximately equal spatial sampling densities and maintaining approximately equal sample sizes for each sampling area. Sampling density was higher in Sampling Area 1.) The selection of minimum sample size is discussed in more detail in Appendix B and the pilot study report.

Specific sampling sites within each sampling area were identified through a multi-step process. First, potential sites were identified by overlaying a map of the EDA sampling area or comparison area with a grid. The grid contained three to four times as many nodes as the number of samples allocated to that area. The nodes were then randomly numbered and chosen in numerical order. A determination was then made regarding whether or not it was feasible to collect a sample at the proposed site. Feasibility included physical feasibility (e.g., a pervious surface) and legal feasibility (e.g., appropriate landowner permissions granted).

The sampling design took into consideration several logistical constraints. Because of the large number of soil samples to be collected, four sampling teams were used so that all field sampling could be completed in a 4-week period. Similarly, seven laboratories were used so that the laboratory analysis could be completed quickly (within 30 days) to meet the study schedule and administrative requirements for sample holding time (see Section 5.2).

To avoid unknown biases that might result from the assignment in the field of specific sampling areas or subareas to specific sampling teams, laboratories, or sampling days, the samples to be collected were randomly allocated prior to field work with the following constraints:

- Samples assigned to a sampling team on a given day should be nearly contiguous (in the same general area) to minimize team travel.

- On each day three sampling teams should be in the EDA and one in a comparison area to optimize the use of surveying crews. (Comparison area sampling points were not surveyed.)

- Each of the four sampling teams should collect no more than a total of 12 field samples each day to allow adequate time for quality assurance documentation.

- Each laboratory should receive approximately equal numbers of samples from each sampling area to balance the effects of interlaboratory variability.

23

- Each laboratory should receive no more than its capacity (six to eight samples) each day to minimize its backlog of samples.

The second major issue in the study design was the development of an analytical method using a GC/MS operating in the SIM mode. This method provided typical operational detection limits in the 0.2- to 0.3-ppb range for the LCICs. Further discussion of the analytical method developed for this study is presented in Section 5.2.

The third element of the study design was the development of an information management system to handle the large volume of data generated. The extensive system designed for this purpose, described further in Section 5.3, ultimately produced a final data base containing the data collected during the study.

4.3 DATA QA/QC DESIGN

As discussed in Section 3.0, Goals, the study was designed to provide data of known, defensible quality. To achieve this goal, several data QA/QC objectives were selected; these objectives relate to the data's precision, accuracy, representativeness, completeness, and comparability. The following paragraphs define the data QA/QC objectives and briefly summarize how each is achieved and measured. The sample collection and analysis QAPPs provide more detailed discussions of the QA/QC measures. Section 5.4 describes the overall study QA/QC program, and Section 6.2 provides an overview of the QA/QC data assessment.

Precision

Precision is a measure of the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average value. The study design provided for laboratory precision to be measured by splitting the field samples and sending the splits to the same or to different laboratories. The design provided for laboratory precision also to be measured by splitting samples with known "spiked" contaminant concentrations and analyzing both splits at the same laboratory.

Accuracy

Accuracy measures the bias in a measurement system. Bias in this study may result from procedures or contamination associated with sample collection, shipment, preparation, or analysis. The study was designed to measure contamination bias in these processes by introducing "blank" samples and evaluating the results. The design also provided for the measurement of potential bias in the sample analysis through the use of QC samples and spiked samples.

Representativeness

Representativeness is a qualitative measure of how well the soil sample represents the surrounding soil and is a measure of how well the measured results reflect the actual concentration or distribution of the chemical compounds in the sampled soil. Sampling protocols were designed to obtain soil samples that were representative of the areas sampled, and sample handling protocols were developed to preserve the integrity, and thus the representativeness, of the collected samples. Analytical protocols and analyses of spiked samples allowed a qualitative assessment of the representativeness of measured results with respect to actual concentrations in the soil sample.

Completeness

Completeness is a measure of the amount of valid data obtained from the analytical measurement system. It is defined as the total number of samples for which acceptable analytical data are generated, divided by the total number of samples collected, and multiplied by 100. The completeness objective for this study was to obtain valid analytical data for at least 90 percent of the samples collected during the study.

Comparability

Comparability is a parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. Comparability for this study was designed to be achieved by the use of a narrowly defined laboratory statement of work; training of laboratory personnel; practice and performance evaluation on the analytical method; use of standard glassware and the same batches of solvents and reagents by all the laboratories; strict quality control criteria for sample analysis; onsite inspections; and close daily monitoring of laboratory work quality through electronic data transfer and telephone contact.

The design criteria and issues described in this section formed the basis for the study methods selected and developed. Section 5.0 provides a discussion of these methods.

5.0 METHODS

To fulfill the project goals and design criteria described in Sections 3.0 and 4.0, methods were developed for sample collection and preparation, sample analysis, data management, QA/QC, and statistical analysis. A description of these methods follows.

5.1 SAMPLE COLLECTION AND PREPARATION

Field sample locations were identified as discussed in Section 4.2, Study Design. The location of each EDA field sample was established relative to the New York State Planar Coordinate System (using a permanent benchmark) prior to sampling. Surveying these locations in the EDA was essential in the event that there was a need to locate the sample site for remediation. Comparison area field sample locations were not surveyed, but their locations relative to permanent structures were measured and documented.

At each field location, leaf litter and sod were removed before the sample was collected with a Zero Contamination Sampler (a stainless steel hand sampler with a removable, 12-inch-long, 1-inch-internal-diameter, stainless steel liner). To satisfy the minimum soil volume requirements for the analytical method, the minimum length of a collected sample was established as 7 inches. The Zero Contamination Samplers were decontaminated between sample locations.

The removable liners housing the samples were individually packaged, placed in coolers, and surrounded with refrigerant packs for shipping at a temperature of approximately 4°C. The coolers were then sent via overnight delivery to the preparation laboratory where the soil was extruded from the liner and mixed prior to shipment to the analytical laboratories. Further details of the field sampling methods can be found in the sample collection and preparation QAPP (CH2M HILL, 1987a).

As each sample was collected, a sample collection form preprinted with sample station number and property address was completed by the sampling team. Chain-of-custody forms were completed for each sample, and traffic reports were completed daily for each cooler of samples shipped. Data from the sample collection forms were cross-checked for discrepancies, and the discrepancies were investigated and resolved. The sample collection form data were entered daily into the sample collection data base using double data entry with a computerized cross-check of the entered data.

After the coolers with the samples were received at the preparation laboratory and their contents verified, the liners were placed in refrigerated (4°C) storage until preparation later that day. The preparation process included extruding the soil from the liner using a stainless steel hydraulic extruder, hand-mixing the soil in a pan for 90 seconds using a spoon, and filling a glass jar with the mixed soil sample. The head space in the jar was to be minimal, so any head space was measured and noted. The extruder head was decontaminated after each sample was prepared. The jars were packaged, placed in coolers, surrounded with refrigerant packs, and shipped at approximately 4°C to the analytical laboratories.

Data from the preparation laboratory activities were recorded using data systems developed specifically for this program (see Section 5.3). The sample preparation forms generated by the data system provided information including the sample number and the analytical laboratory to which the sample was to be sent. Sample preparers entered the station number of the sample, along with the date and time the sample was prepared, and signed the form. The system then generated corresponding chain-of-custody forms and traffic reports for shipment of the samples.

5.2 SAMPLE ANALYSIS

The analytical method used for sample analysis in this study was developed to meet the study objective of achieving the lowest technically feasible detection limits. (The typical operational detection limit was 0.2 to 0.3 ppb for the LCICs.) To allow the sample collection schedule to be somewhat independent from the sample analysis schedule, the maximum allowable sample holding time for extraction (an administrative requirement limiting the time from sample collection to sample extraction) was increased from the 10-day period used during the pilot study to 30 days, as discussed later in this section. An overview of the analytical method and its development is provided below.

Analytical Method

A protocol using GC/MS/SIM for the analysis of soil samples for LCIC concentrations was developed, validated, and successfully used for the pilot study. GC/MS operating in the SIM mode was chosen as an instrumentation technique that could provide suitable detection limits and selectivity for LCIC analysis. During the pilot study, LCICs were typically identified using this technique at concentrations as low as 1 ppb.

Based on the experience gained from the pilot study, a number of modifications to the method were made prior to this soil assessment to achieve lower detection limits and reduce chemical interferences for the BHC isomers. These changes lowered the typical operational detection limits by a factor of five, from about 1 ppb to 0.2 ppb for most of the LCICs. The actual, but unmeasurable, detection limits for a particular sample depended on the individual LCIC, sample interferences, and the GC/MS/SIM instrument. Modifications made to reduce the hydrocarbon interferences allowed two additional BHC isomers, alpha- and delta-BHC, to be analyzed with the method, thus replacing the LCIC "total BHC" with its component isomers, alpha-, beta-, gamma-, and delta-BHC. Other modifications were made to increase laboratory throughput.

In general, the analytical method consisted of solvent extraction, extensive cleanup, and analysis by GC/MS/SIM. To obtain low detection limits, reliable LCIC identification, and accurate quantification, an analytical protocol was developed that detailed extraction procedures as well as calibration procedures and specified instrument parameters.

The initial development of the analytical method is described in the pilot study report (CH2M HILL, 1987c). Modifications made to the analytical method after the pilot study are summarized in more detail in Appendix C of this document. A detailed description of the analytical method can be found in the soil sample laboratory analysis QAPP (CH2M HILL, 1987b).

Holding Time Study

The administratively defined laboratory holding time for sample extraction was increased from 10 days to 30 days. During the pilot study, the holding time from sample collection to extraction was 10 days (the time typically allowed by the EPA's Contract Laboratory Program), and the holding time from collection to analysis was 50 days. In order to allow decoupling of the field and laboratory schedules, the holding time from sample collection to extraction was increased while retaining the overall holding time from collection to analysis. (Decoupling of the field and analytical schedules became necessary when the field sampling schedule was accelerated to allow sampling to be completed before the onset of inclement winter weather.) There was no evidence during the pilot study that an increased extraction holding time would affect the concentration of LCICs in the soil samples.

A holding time experiment was initiated prior to the start of sample analysis to study the effect of extending extraction holding times; this experiment proceeded concurrently with the soil assessment. The results of the holding time study verified that extending the 10-day holding time during this study did not have a significant effect on the concentrations of LCICs in the sample. It should be noted that holding time effects, if any, would not affect the results of the designed statistical comparisons, because the sequence of sample collection (and subsequent analysis) was randomized. A more complete discussion of the holding time study design and results is provided in Appendix D.

5.3 DATA AND INFORMATION SYSTEMS DEVELOPMENT

A large volume of data was generated throughout the study, from the random selection of field sample sites, through sample collection and preparation, to the analytical results and their validation. An information management system was developed to capture, manage, and maintain the data, and to provide a final data base containing all the data collected during the study. The system expedited the study schedule by tracking samples, maintaining shipment information, facilitating QA/QC of the analytical results, and minimizing transcription errors.

On the basis of the experience gained from using software systems during the pilot study and soil assessment for dioxin, software requirements and a data flow diagram of the project's information environment were developed. (More details are provided in Appendix E.) The subsequent design of the overall information management system was influenced by two primary considerations: the diverse locations of study activities and the complexity of the data collection and storage. Study activities occurred concurrently in separate geographic locations across the country. Processing capabilities and functions were therefore designed for personal computers wherever possible. In addition, a project communications link was established between the various project systems and personnel.

Virtually all data generated during each phase of the study were stored through the use of software systems. The systems tracked the chain-of-custody, linked the analytical results and the sample locations, and supported the complex analytical requirements of the study. The analytical data were generated and captured electronically on each analytical instrument's microprocessor.

Based on the software requirements for the study and the existing software from both the pilot study and the soil assessment for dioxin, separate software systems were designed. The 10 major software systems addressed site selection, sample collection, tracking sample preparation, sample analysis, real-time (analytical) QC, data validation, double data-entry, data base modeling, data base integration, and project-wide communications.

Eight of these systems were implemented on personal computers, while two were implemented on the EPA mainframe system. The systems were designed to be user-friendly and to provide editing capabilities. A Statistical Analysis System (SAS) relational data base was used for the resulting integrated data base, which includes 1.8 million cells of data. Appendix E contains additional details on these systems.

5.4 QA/QC PROGRAM

As discussed in Section 4.3, the QA/QC program was designed to provide data that are precise, accurate, representative, complete, and comparable. This section summarizes the QA/QC methods used in the study, while Appendix F provides a more detailed program description. Specifically, QA/QC methods were incorporated into each phase of the study to achieve the following:

- *Provide accurate field sample location information*--This was achieved using several procedures. The EDA sample location was surveyed, and the documentation was filled out by the survey crew and the sampling crew. The documentation was checked for completeness and cross-checked for discrepancies. Missing information and discrepancies were resolved and corrected. After sampling, a map was generated showing the points sampled. The map was then cross-checked against the survey documentation, and discrepancies were resolved and corrected.

- *Minimize and assess cross-contamination of samples*--This was accomplished by implementing QA/QC procedures in the sample collection and preparation processes. Blank samples were interspersed at various stages in the sample collection, preparation, and analytical sequence to allow for a measure of cross-contamination, decontamination efficiency, and potential errors that might be introduced from sources other than the sample.

- *Maintain correct link between analytical results and sample locations*--Documentation was generated electronically, assigning the sample identification number in the sample preparation laboratory. The sample retained this identifier through the entire laboratory analytical process. Documentation of sample shipment and chain-of-custody was prepared, the documentation was cross-checked for discrepancies, and discrepancies were resolved. All data entered in the electronic data management system were reviewed and the functioning of the data-storage software was checked to verify that the system was operating correctly. The data entered in the system were merged, and the merge was checked to provide the correct link between analytical results and sample locations.

- *Minimize variability among laboratory performances*--Using the newly developed analytical procedure detailed in the sample analysis QAPP, a training session was conducted for the staff of each of the analytical laboratories and evidentiary and technical audits were conducted at each laboratory to assess whether the laboratory had followed the QAPP. The evidentiary audits are documented in Appendix G. A real-time QC system also was used to monitor the laboratory performance. Standard glassware was used by all the laboratories to minimize variability introduced by using slightly different glassware.

- *Minimize potential for laboratory contamination and assess laboratory contamination*--On a project-wide basis, all solvents and materials were analyzed. Batches with the lowest levels of contamination were identified, and a single source of solvents and reagents was used for all the laboratories to minimize this potential source of contamination. In addition, strict cleanup protocols were incorporated into the analytical method. QC samples were used to assess whether contamination had occurred, and appropriate actions were taken to eliminate discovered sources of contamination and to reanalyze samples discovered to be potentially affected.

- *Assess ongoing laboratory performance*--The analytical process included the analysis of QC samples designed specifically to assess the accuracy and overall performance of the analytical process at each laboratory. Each laboratory internally reviewed and assessed the results of its analytical process. Blind QC (BQC) samples were sent to the laboratory, and the results were reviewed by an independent agency review team (EMSL-LV/LEMSCo). In addition, a computerized system allowed online monitoring of the laboratory performance and a review of the results by the prime contractor and the independent agency review team. Problems in laboratory performance were then expeditiously corrected.

- *Assess validity of data*--The final analytical data were assessed and validated by the independent agency review team. The team flagged the analytical results with data qualifiers and data usability flags. The data usability flags indicated the results that were recommended for use in the statistical comparisons. The data validation efforts are reported in Appendix H.

- *Conduct evidentiary audits*--Evidentiary audits were conducted on the field sampling, sample preparation, and analytical activities. The results of these audits are reported in Appendix G.

The specific QA/QC activities and measures in the field sampling, laboratory analysis, information management, and statistical comparison phases are described in more detail in Appendix F. The sample collection and preparation QAPP and the sample analysis QAPP fully document the design of the QA/QC measures for these phases of the project.

5.5 STATISTICAL ANALYSIS

As described in Section 3.0, the goal of the sampling program was to be able to compare each EDA sampling area with each comparison area so that there was a 90 percent probability of detecting an order-of-magnitude difference in median concentrations with 95 percent confidence. The motivation for the conceptual framework used in the statistical sampling design reported in Section 4.2 was to minimize the influence of external factors in the statistical comparisons, while maximizing the ability to detect differences between EDA sampling areas and comparison areas. This section describes the choice of statistical methods used for the comparisons and the basis for their selection. The results of the statistical analysis of the data are presented in Section 6.4.

As in Section 4.3, some of the issues discussed here require the use of statistical terminology. An attempt is made to minimize the use of technical terminology; however, the reader unfamiliar with basic statistical concepts may find it desirable to read Appendix A before proceeding. Appendix B provides a more in-depth and technically oriented discussion of the study's statistical design and methods.

As discussed in Section 4.2, the statistical design and the statistical analysis methods are closely linked. The objective of the statistical comparison analysis was to produce a high level of confidence that the analysis would detect true differences in concentrations between sampling areas if such differences exist. To accomplish this, the statistical analysis methods had to be able to deal with the following characteristics of the data set:

- The concentration estimates are never negative. They are usually small (or non-detect) and also have a few high values.

- The number of non-detectable concentrations for some LCICs is quite high.

In addition, the habitability criteria required a version of the statistical test that could analyze for differences between areas using all the LCICs together as one data group (the multivariate statistical test).

Many statistical methods that are available are particularly applicable to the comparison approach. These methods can be broadly divided into two groups: parametric and nonparametric. Parametric methods require knowledge (or an assumption) about the statistical distribution of the data; nonparametric methods do not. If one applies any statistical test to data that are not consistent with the underlying assumptions, then the resulting statistical comparisons may be invalid. The degree to which a statistical test will provide acceptable performance if the assumptions are violated is known as "robustness." In general, nonparametric tests are more robust than parametric tests. Extensive computer simulations were conducted to evaluate the robustness of several candidate parametric and nonparametric statistical tests. The results of these studies are reported in Appendix B.

In the computer simulations, the test found to have the best overall performance was the nonparametric Wilcoxon rank-sum test (Hollander and Wolfe, 1973). The Wilcoxon rank-sum test is so named because it uses a test statistic that is based on the sum of the ranks. For example, to compare two areas, all of the concentrations from both areas are ranked together from lowest to highest. Nondetectable concentrations are all given the same rank. All of the ranks from each area are then summed and standardized to form the test statistic. The test statistic is expected to be small if two areas being compared are similar. If the test statistic is larger than a critical value, the null hypothesis (the hypothesis that is accepted unless there is sufficient evidence to the contrary) that the areas are similar is rejected. Critical values of the test statistic can be found in standard statistical references (e.g., Hollander and Wolfe, 1973).

Robustness and sensitivity are related yet distinct issues that have important implications for the choice of a statistical method. As described above, robustness refers to the performance of a statistical test when the test assumptions are not met; robustness is best assessed using computer-simulated data with characteristics as similar as possible to the real data to which the test would ultimately be applied.

In contrast, the term "sensitivity" in statistical analysis refers to an evaluation of specific changes in results (that is, the conclusion of whether two sampling areas are or are not different at a given significance level) that would occur if specific data values were changed. The Wilcoxon rank-sum test was evaluated for its sensitivity to the soil assessment data by using three variations of the basic data set. The first variation consisted of all of the validated data deemed usable for the statistical comparisons. These data were designated as "Good." The second consisted of the Good data plus the data that were of somewhat uncertain validity (designated "Uncertain") according to QC criteria. (Assessment of data validity is discussed further in Section 6.1.) The third variation was identical to the first, except that all data values below 1 part per billion (ppb) were treated as non-detectable (the actual operational detection limit was sample-dependent, but was estimated to be typically 0.2 to 0.3 ppb).

The three alternate data sets served to provide a qualitative measure of the sensitivity of the statistical analyses. The inclusion of Uncertain data as well as Good data in the analysis was intended to allow evaluation of the sensitivity of the statistical analysis to variations in laboratory analytical quality. Artificially increasing the detection limit to 1 ppb and analyzing the resulting data set made it possible to assess the sensitivity of the statistical analysis to the laboratory detection limits. If the results had changed dramatically with the increased detection limits, then it could be concluded that the detection limits were exerting a strong influence on the results.

6.0 RESULTS

The results of the soil assessment for LCICs include the samples actually collected and analyzed, study performance in relation to the QA/QC objectives, and the statistical comparisons between EDA sampling areas and comparison areas.

The sampling and analytical activities are summarized in Section 6.1. This includes an accounting of the number of field samples and quality control samples involved in the study. Section 6.2 provides an overview of the QA/QC data assessment. The analytical results are reported in Section 6.3. Section 6.4 reports the results of the statistical comparisons. As directed by the TRC, the purpose of this assessment is to present data and is specifically not to develop conclusions or interpretations of the data.

6.1 SAMPLING AND ANALYTICAL ACTIVITIES

Collection of soil samples began in October 1987 and ended in November 1987. Figures I-1 through I-11 of Appendix I show the locations of the samples collected in the seven sampling areas of the EDA and the three comparison areas (combined Cheektowaga and Tonawanda, Census Tract 221, and Census Tract 225), respectively. Table 6-1 shows the number of samples collected in each of the areas mentioned above. As indicated by Table 6-1, a total of 887 field samples were collected out of the 894 planned. Five samples were not collected because of field conditions such as gravel or standing water, and two samples were not collected because permission to sample was revoked. The sampling design specified that the collection of samples be randomly allocated among collection teams and neighborhoods. Table 6-2 shows the number of samples actually collected during the field sampling by the four collection teams in each neighborhood.

Of the 887 field samples collected, 866 were extruded, prepared, and sent for analysis (Table 6-1). Twenty-one regular field samples could not be extruded. Sixteen unextrudable samples were replaced with 16 other samples taken approximately 5 feet away from the original locations. These samples are referred to as "replacement samples" in Table 6-1 and are identified with an "R" suffix (e.g., 444R) on the maps (Figures I-1 through I-11). Three of

Table 6-1

NUMBER AND TYPE OF FIELD SAMPLES COLLECTED AND SENT FOR ANALYSIS

EDA Sampling Areas[a]	EDA Neighborhood	Samples Planned for Collection	Samples Actually Collected	Unextrudable Samples	Replacement Samples	Samples Sent for Analysis	Contingency Samples Available for Analysis
1	1	50	47	0	0	47	7
2	2	48	48	2	1	47	4
	3	52	52	2	2[b]	50	4
		100	100	4	3	97	8
3	4	70	69	2	1	68	3
	5	35	35	1	1	35	3
		105	104	3	2	103	6
4	6	85	84	0	0	84	8
5	7	35	36	1	1	36	6
	8	35	35	1	0	34	3
	9	35	35	2	2[b]	34	6
		105	106	4	3	104	15
6	11	35	35	1	1	35	5
	12	73	72	0	0	72	4
		108	107	1	1	107	9
7	10	35	35	0	0	35	8
	13	81	82	0	0	82	2
		116	117	0	0	117	10
Total EDA		669	665	12	9	659	63
Comparison Areas:							
Census Tract 221		75	73	8	6	71	3
Census Tract 225		75	75	1	1	75	7
Tonawanda		37					
Cheektowaga		38					
		75	74	0	0	74	3
TOTAL STUDY		894	887	21	16	879	76

---

[a] A sampling area consists of one or more neighborhoods as indicated.

[b] Both replacement samples for Neighborhood 3 were unextrudable; one replacement sample for Neighborhood 9 was unextrudable.

Table 6-2

NUMBER OF FIELD SAMPLES COLLECTED BY SAMPLING AREA, NEIGHBORHOOD, AND SAMPLING TEAM

EDA Sampling Area	EDA Neighborhood	Sampling Team 1	Sampling Team 2	Sampling Team 3	Sampling Team 4	Total
1	1	13	10	12	12	47
2	2	17	7	12	12	48
	3	16	12	12	12	52
		33	19	24	24	100
3	4	16	24	17	12	69
	5	12	0	12	11	35
		28	24	39	23	104
4	6	20	12	28	24	84
5	7	10	1	13	12	36
	8	8	13	2	12	35
	9	14	3	12	6	35
		32	17	27	30	106
6	11	0	12	11	12	35
	12	15	18	18	21	72
		15	30	29	33	107
7	10	12	3	8	12	35
	13	29	9	12	32	82
		41	12	20	44	117
Total EDA		182	124	169	190	665
Comparison Areas:						
Census Tract 221		13	35	16	9	73
Census Tract 225		12	26	25	12	75
Tonawanda/Cheektowaga		11	30	21	12	74
TOTAL STUDY		218	215	231	223	887

the replacement samples also had extrusion problems and were not themselves replaced. In addition, 78 contingency samples were collected in the event additional samples were needed for analysis; two of these were unextrudable.

The resulting 879 extruded and prepared samples (Table 6-1) were sent to seven analytical laboratories for analysis of the LCICs. Table 6-3 shows the number of samples that each laboratory was planned to have received, the number actually received, and the number of samples that each laboratory analyzed. As shown in Table 6-3, 781 samples were actually analyzed for the LCICs. Ninety-seven samples were not analyzed because of problems at Laboratory 4, as discussed below. One sample was not analyzed at Laboratory 3. Figures 6-1 through 6-5 show the locations of the 781 samples that were analyzed in the EDA, Cheektowaga, Tonawanda, Census Tract 221, and Census Tract 225, respectively.

The electronic and hardcopy data provided by the laboratories were subjected to a detailed data assessment process by EMSL-LV, described in Appendix H. This resulted in an assignment of data qualifiers to each sample and each LCIC analyte within a sample. From these data qualifiers, an overall assessment of the usability of the results for the statistical comparison was made. Each LCIC result was defined as being Good, Uncertain, or Bad. It should be noted that the definition of usability of the results was not related to the concentration estimates. Only results classified as Good were used in the statistical comparisons. (Results initially classified as Uncertain based only on holding time violations were reclassified as Good for purposes of statistical analysis.) Table 6-4 presents a summary of the Good data used for the statistical analysis by LCIC, for the 781 samples analyzed.

Table I-1 in Appendix I shows the final, validated results for all field samples by LCIC. Analyses that yielded Uncertain or Bad data are designated in the table as not meeting QC criteria. This table is discussed further in Section 6.3.

The nominal or desired allocation of samples is discussed in Section 4.2. A first step in assessing design implementation was to compare the actual allocation of samples to the planned allocation of samples, as shown in Tables 6-1 through 6-3. In all cases, the differences were minor. The agreement between the actual and planned sample allocations confirms that the

Table 6-3

NUMBER OF FIELD SAMPLES RECEIVED AND ANALYZED BY LABORATORY

Analytical Laboratory[a]	No. of Samples Planned	No. of Samples Received	No. of Samples Analyzed
1	122	119	119 + 38[b]
2	125	121	121
3	128	125	124[c]
4	135	135	0[d]
6	137	137	133[e]
7	110	109	109
8	137	133	137[e]
TOTALS	894	879	781

---

[a] Laboratory 5 was not selected for study participation.

[b] Thirty-eight samples extracted by Laboratory 4 were sent to Laboratory 1 for analysis.

[c] One sample was not analyzed.

[d] Laboratory 4 did not successfully analyze any samples.

[e] Four samples originally designated for Laboratory 6 were accidentally sent to Laboratory 8 for analysis.

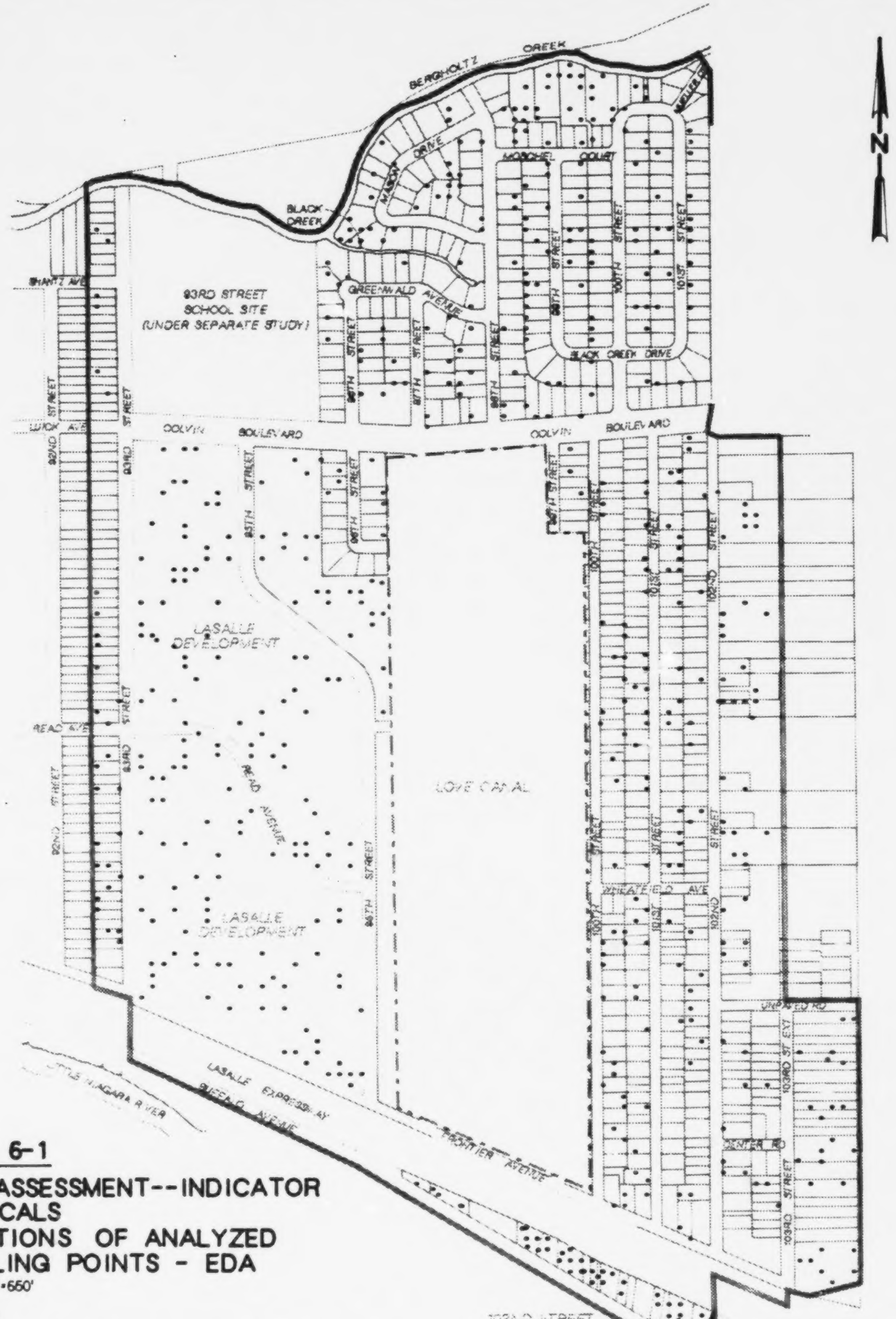
N
BERGHOLTZ CREEK
BLACK CREEK
MOSCHEL COURT
MASON DRIVE
GREENWALD AVENUE
BLACK CREEK DRIVE
93RD STREET SCHOOL SITE (UNDER SEPARATE STUDY)
SHANTZ AVE
LUICK AVE
COLVIN BOULEVARD
92ND STREET
93RD STREET
95TH STREET
96TH STREET
97TH STREET
98TH STREET
99TH STREET
100TH STREET
101ST STREET
102ND STREET
LASALLE DEVELOPMENT
READ AVE
READ AVENUE
LOVE CANAL
WHEATFIELD AVE
UNPAVED RD
103RD STREET
103RD ST. EXT.
CENTER RD
LASALLE EXPRESSWAY
BUFFALO AVENUE
FRONTIER AVENUE
LITTLE NIAGARA RIVER
102ND STREET LANDFILL

Figure 6-1

SOIL ASSESSMENT--INDICATOR CHEMICALS LOCATIONS OF ANALYZED SAMPLING POINTS - EDA

SCALE: 1"=650'

LEGEND

━━ EMERGENCY DECLARATION AREA (EDA) BOUNDARY
— · — FENCE LINE AROUND LOVE CANAL REMEDIATION SITE
• LOCATION OF SAMPLE

SOURCE: EDA BOUNDARIES TAKEN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

Reproduced from best available copy.

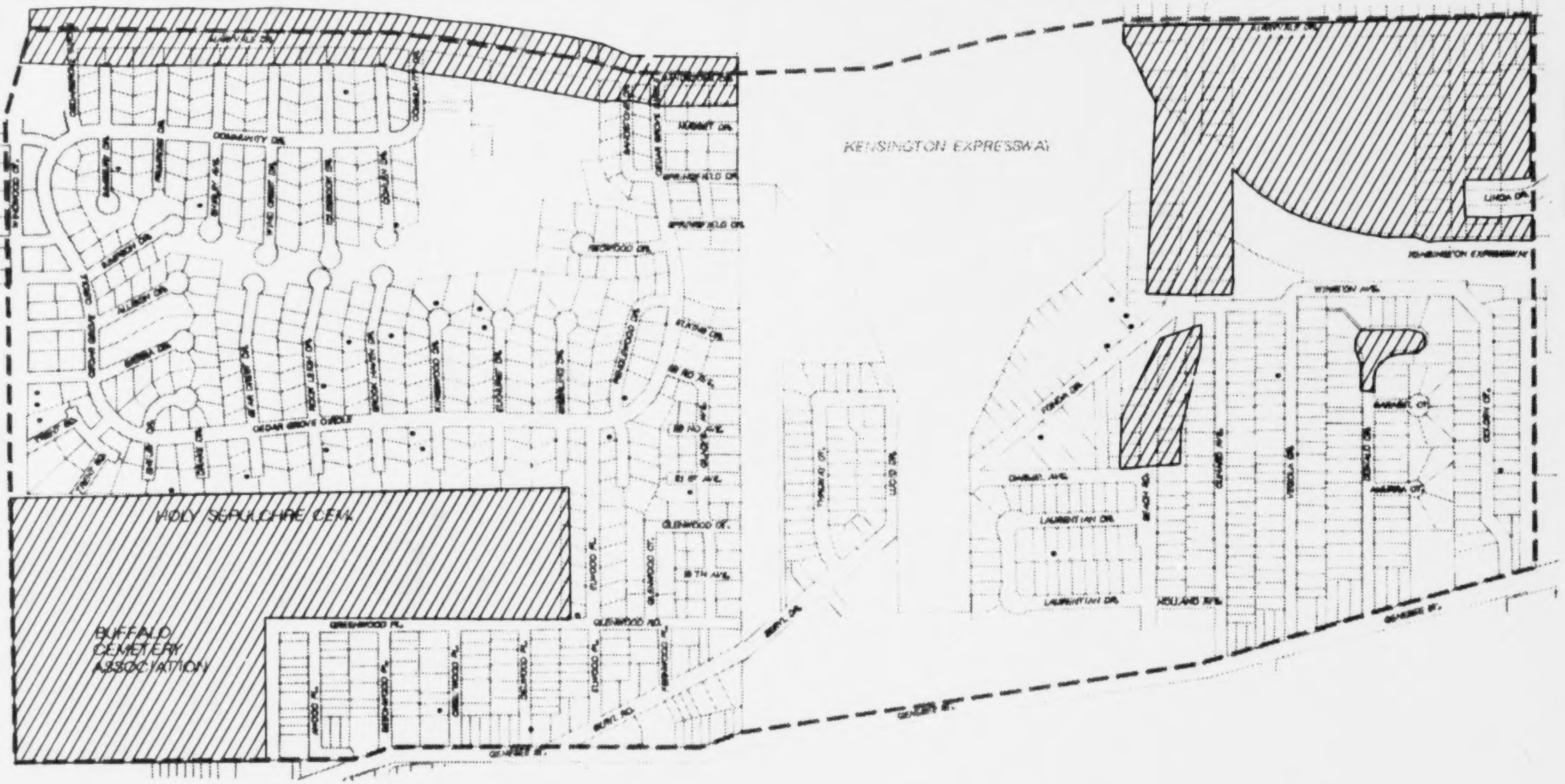
N
KENSINGTON EXPRESSWAY
HOLY SEPULCHRE CEM.
BUFFALO CEMETERY ASSOCIATION
GENESEE ST.
CEDAR GROVE CIRCLE
LAURENTIAN DR.
HOLLAND AVE.
WINSTON AVE.
LINDA DR.

Figure 6-2

SOIL ASSESSMENT--INDICATOR CHEMICALS
LOCATIONS OF ANALYZED SAMPLES
CHEEKTOWAGA COMPARISON AREA

LEGEND

— — SAMPLING BOUNDARY
• SAMPLING POINT
▨ AREA UNSUITABLE FOR SAMPLING AS DETERMINED BY A NYSDOH/NYSDEC/EDA CITIZEN PANEL

SCALE: 1"=650'

SOURCE: MAP DRAWN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

Reproduced from best available copy.

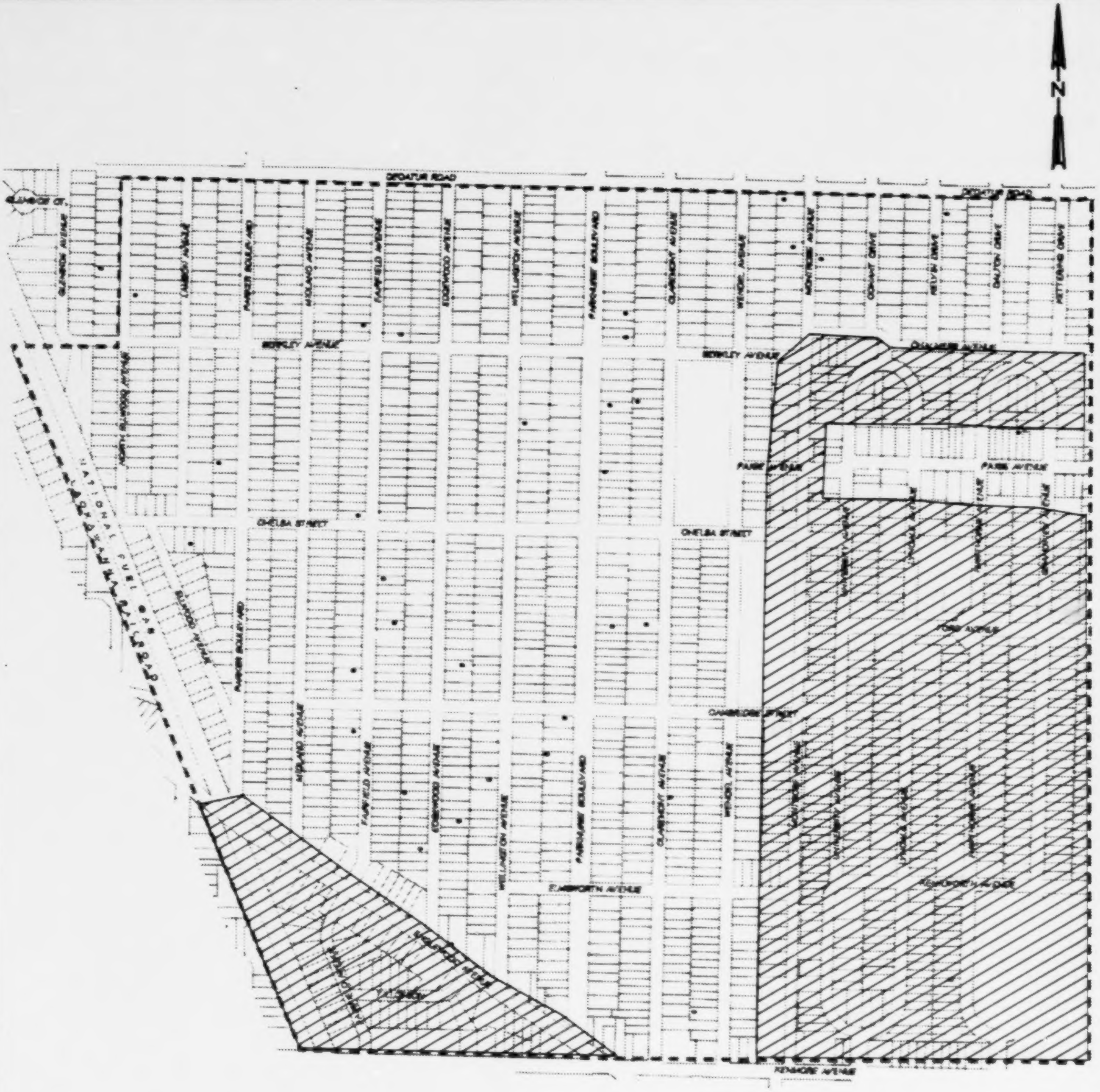
N
DECATUR ROAD
BERKLEY AVENUE
CHALMERS AVENUE
PARK AVENUE
CHELSEA STREET
CAMBRIDGE STREET
KENMORE AVENUE
NATIONAL FUEL GAS

Figure 6-3

SOIL ASSESSMENT--INDICATOR CHEMICALS
LOCATIONS OF ANALYZED SAMPLES
TONAWANDA COMPARISON AREA

SCALE: 1"=650'

LEGEND

- - - SAMPLING BOUNDARY
• SAMPLING POINT
▨ AREA UNSUITABLE FOR SAMPLING AS DETERMINED BY A NYSDOH/NYSDEC/EDA CITIZEN PANEL

SOURCE: MAP DRAWN FROM NEW YORK
STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

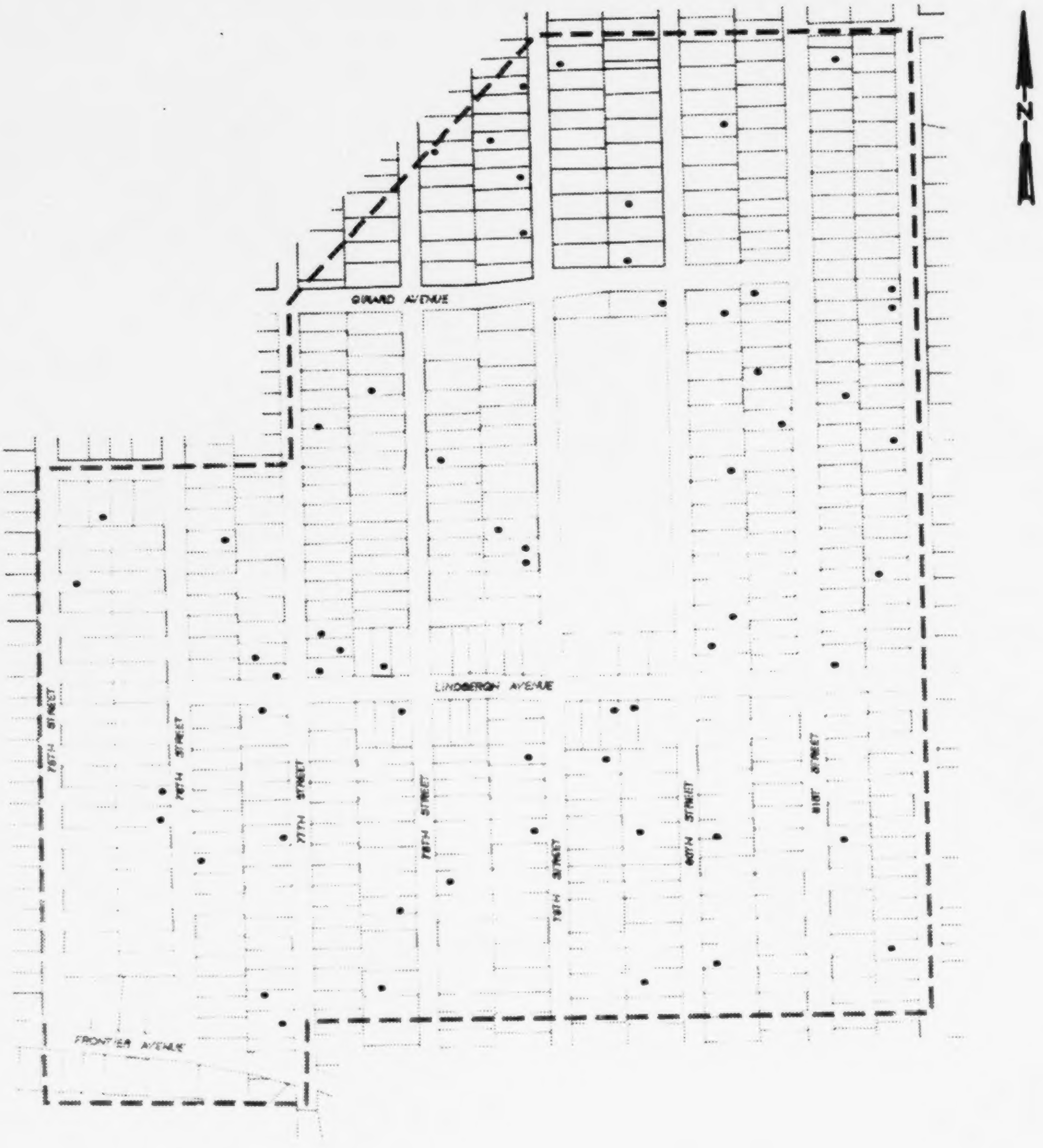
N
GIRARD AVENUE
LINDBERGH AVENUE
FRONTIER AVENUE
75TH STREET
76TH STREET
77TH STREET
78TH STREET
79TH STREET
80TH STREET
81ST STREET

Figure 6-4

SOIL ASSESSMENT--INDICATOR CHEMICALS
LOCATIONS OF ANALYZED SAMPLES
CENSUS TRACT 221 COMPARISON AREA

SCALE: 1"=400'

LEGEND

— — CENSUS TRACT 221 BOUNDARY
• LOCATION OF SAMPLING

SOURCE: BOUNDARIES TAKEN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

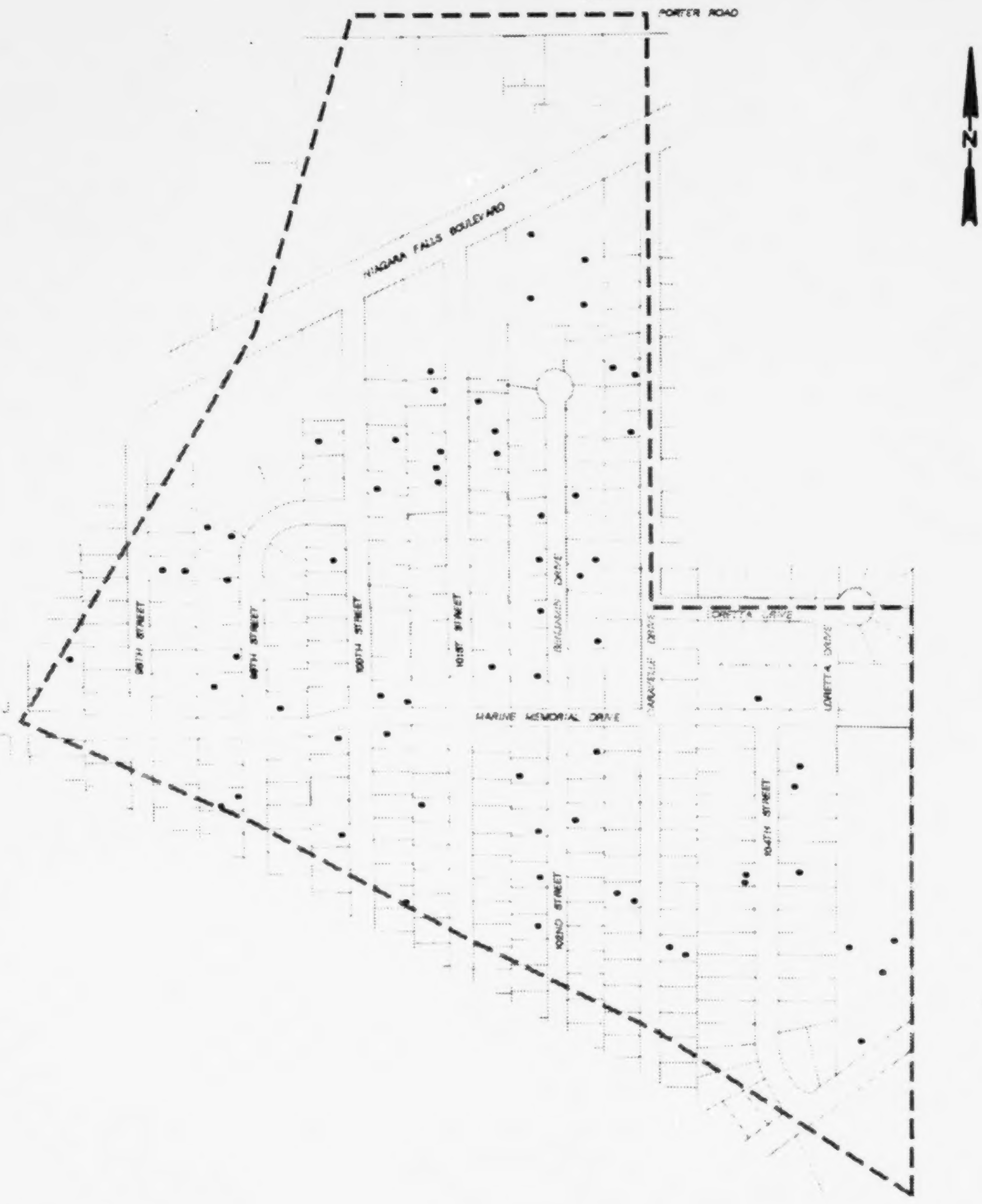
PORTER ROAD
N
NIAGARA FALLS BOULEVARD
98TH STREET
99TH STREET
100TH STREET
101ST STREET
BENJAMIN DRIVE
CARAVELLE DRIVE
LORETTA DRIVE
LORETTA DRIVE
MARINE MEMORIAL DRIVE
102ND STREET
104TH STREET

Figure 6-5

SOIL ASSESSMENT--INDICATOR CHEMICALS LOCATIONS OF ANALYZED SAMPLES CENSUS TRACT 225 COMPARISON AREA

SCALE: 1"=400'

LEGEND

— — CENSUS TRACT 225 BOUNDARY
• LOCATION OF SAMPLING

SOURCE: BOUNDARIES TAKEN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

Table 6-4

SUMMARY OF LCIC RESULTS USED FOR STATISTICAL ANALYSES

LCIC	Number of Samples Analyzed	Number of Individual LCIC Results Designated As Good[a]		Number of Individual LCIC Results Designated As Uncertain[a]		Number of Individual LCIC Results Designated As Bad[a]	
		Number	%	Number	%	Number	%
1,2-Dichlorobenzene	781	655	84	73	9	53	7
1,2,4-Trichlorobenzene	781	685	88	48	6	48	6
1,2,3,4-Tetrachlorobenzene	781	676	86	53	7	52	7
2-Chloronaphthalene	781	640	82	43	6	98	12
Alpha-BHC	781	685	88	52	7	44	5
Delta-BHC	781	673	86	61	8	47	6
Beta-BHC	781	634	81	96	12	51	7
Gamma-BHC	781	681	88	50	6	50	6
Total All Analytes	6,248	5,329	85	476	8	443	7

---

[a] Only results that were designated as Good were used in the statistical analyses.

Table 6-5

NUMBER OF FIELD QC SAMPLES RECEIVED AND ANALYZED BY LABORATORY

Analytical Laboratory[a]	Field QC Samples Received				Field QC Samples Analyzed			
	FHB	Split	PHB	SSB	FHB	Split	PHB[f]	SSB[f]
1	14	22	8	19	14+3[d]	22	–	–
2	12	17	7	18	12	17	–	–
3	11	6	10	19	11	6	–	–
4	12	11[b]	9	21	0	11	–	–
6	11	14	6	18	11	14	–	–
7	10	9	7	17	10	9	–	–
8	6	4	9	18	6	4	–	–
TOTALS	76	83	56[c]	130	67[e]	83	–	–

FHB = field handling blank
PHB = preparation handling blank
SSB = shipping and storage blank

[a] Laboratory 5 was not selected for study participation.

[b] One split was not sent to Laboratory 4.

[c] A total of 57 PHBs were used; however, one was unextrudable.

[d] Three of Laboratory 4's FHBs were analyzed by Laboratory 1.

[e] Nine FHBs were not analyzed by Laboratory 4.

[f] PHBs and SSBs were stored but not analyzed.

original randomization was maintained with respect to the sampling crew and sample analysis.

Four types of field QC samples were used during sample handling and tracking, as discussed in Appendix F. They included field handling blanks, splits, preparation handling blanks, and shipping and storage blanks. Table 6-5 presents information regarding the number of field QC samples received and subsequently analyzed by each analytical laboratory. Upon QC review of the field sampling it was discovered that the allocation of split samples to analytical laboratories deviated from the planned allocation. Only two of the intra-laboratory split samples were generated. This limited the opportunity to assess intra-laboratory variability using split samples. Intra-laboratory variability, however, can also be assessed by other QC samples, e.g., BQC samples. (The results of these analyses are given in Appendix H.)

Four types of laboratory QC samples were used:

- Method/holding blanks (MHBs)--1 in 10 analyses
- BQCs--1 in each batch of samples (approximately 10)
- Matrix spike/ matrix spike duplicates (MS/MSDs)--1 in 20 analyses
- EPA check standards--once every 2 weeks

These QC analyses totaled approximately 500.

Only two problems were encountered during the sample analysis. First, early in the laboratory analysis phase of the project it was discovered simultaneously in several laboratories that an interfering chemical was present in the MHBs. This chemical interfered with measurements of beta- and gamma-BHC. An investigation was initiated in all laboratories to isolate and eliminate the source of contamination. It appeared that the interference was from the detergent commonly used to clean the laboratory glassware. The laboratories took appropriate corrective actions to resolve the problem. Corrective actions included minimizing the use of detergent, using more efficient rinses after the glassware had been washed, and adjusting the GC/MS so that the interfering compound was separated from the target LCICs.

Second, one laboratory experienced considerable difficulty in successfully analyzing the samples. This laboratory, designated Laboratory 4, encountered instrumentation problems early in the study. Once the GC/MS instrument was functioning properly, the blank interference problem discussed above was discovered. Because of these problems, the BQC samples from Laboratory 4 were analyzed by Laboratory 1. Once these samples were analyzed, it was found that only five of the remaining batches had acceptable BQC samples. The field samples and associated QC samples from these five batches were analyzed by Laboratory 1, and the data from these samples were subjected to data validation by EMSL-LV.

6.2 QA/QC DATA ASSESSMENT

As discussed in Sections 3.0 and 4.3, the study was designed to achieve the QA/QC objectives of precision, accuracy, representativeness, comparability, and completeness as specified in the sample collection and analysis QAPPs (CH2M HILL, 1987a and 1987b). This section summarizes the results of the QC sample analysis, while Appendix J provides a more detailed discussion.

Table 6-6 summarizes the results of all QC sample data. QC control limits were set for the various measures of QC samples. The QAPP-specified goal was that the laboratories should meet the QC control limits for either 90 percent or 100 percent of the analyses, depending on the type of measure involved. This goal was met for all types of QC measures, with the minor exception of MS/ MSD analyses. MS and MSD samples are two separate portions of the same field sample, each of which is spiked with a known amount of LCICs.

The MS/MSD samples were analyzed to assess the accuracy and precision of the analytical method. The accuracy is measured by the "recoveries," i.e., the laboratory's ability to measure the spiked concentrations. Stringent QAPP advisory control limits were developed for MS/MSD recoveries, based on method validation results from the two laboratories used in developing the method. When the six laboratories used for the soil assessment analyzed the QC samples, none achieved the goal of meeting the QC criteria for 90 percent of the analyses. The control limits were not revised because the time constraints did not permit a second multi-laboratory MS/MSD study.

50

Table 6-6
QC DATA SUMMARY

QA Measure	Laboratory	Data Meeting QC Criteria Goal (%)	 Achieved (Y or N)
MHB	1	90	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Surrogate Spike Recovery	1	90	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
MS Recovery (Advisory Only)	1	90	N
	2		N
	3		N
	6		N
	7		N
	8		N
MSD Precision (Advisory Only)	1	90	Y
	2		Y
	3		N
	6		Y
	7		Y
	8		N
BQC Recovery	1	90	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y

Table 6-6
(continued)

		Data Meeting QC Criteria	
QA Measure	Laboratory	Goal (%)	Achieved (Y or N)
EPA Check Standard Recovery	1	100	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Internal Standard Area and Retention Time Variation	1	90	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Performance Check Standard (PC1 and PC2)	1	100	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Initial Calibration Standard	1	100	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Continuing Calibration Standard	1	100	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Holding Time (for original extraction and analysis only)	1	100	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y

The samples were not reanalyzed because these control limits were advisory only.

Most of the laboratories (four of the six) did meet the 90 percent goal for MS/MSD precision; that is, the measured values for both MS and MSD samples were within the specified range. As Table 6-6 shows, the 90 percent or 100 percent goals were met for all other QC measures.

6.3 DETECTION LIMIT AND ANALYTICAL RESULTS

Detection Limit

Previous Love Canal studies and the pilot study have indicated the major importance of achieving an understanding of the detection limits for the LCICs in soil samples from the Niagara Falls area. Unfortunately, there is no generally accepted approach for estimating detection limits. For a method using GC/MS/SIM, at best an estimated detection limit can only indicate the typical performance of the analytical method in a given laboratory for an LCIC. The actual detection limit for an individual sample, which cannot be measured, depends on the LCIC in question, the level of interferences in the sample, and the performance of the GC/MS instrument at the time of analysis.

For this analysis, there is an additional complicating factor in that LCICs need to be both detected and identified. As was observed in the pilot study, the qualitative identification criteria are often more difficult to satisfy than the detection criteria.

The operational detection limit was estimated based on the large number (ranging from 62 percent of 2-chloronaphthalene to 12 percent of delta-BHC) of LCIC results reported for field samples at concentrations below 0.3 ppb. The operational detection limit is estimated to be between 0.2 and 0.3 ppb. This estimate is also supported by the performance of the laboratories on the BQC samples at this concentration level, as discussed in Appendix J.

Analytical Results

Table I-1 of Appendix I shows the final, validated results for all field samples and each LCIC within a sample. LCIC concentrations are reported only for results designated as usable for the statistical comparisons. These data are designated as Good. Results in which LCICs were not detected are listed as ND. Analytical results that were classified as Uncertain or Bad are listed as QCF. Samples that were not taken and were not analyzed (contingency samples) are designated as NT and NAC, respectively. Samples that were not analyzed because of Laboratory 4's problems described in Section 6.1 are listed as NA.

Tables 6-7a through 6-7h summarize the analytical results for each of the seven EDA sampling areas and each of the three comparison areas.

Graphic Representations of Analytical Results

Histograms and box plots were used to visually compare the LCIC concentration data from the EDA sampling areas to the corresponding data from the comparison areas. Although these graphic representations are not a substitute for formal statistical analysis (discussed in Section 6.4), they should be generally consistent with the statistical analysis and accordingly provide a qualitative cross-check of the results of the statistical comparisons. The following paragraphs discuss the histograms and box plots in more detail.

Histograms. Histograms are graphic representations of the concentrations of each of the LCICs in each of the EDA sampling areas and comparison areas. Figures 6-6a through 6-6h are histograms illustrating the distribution of concentrations found for each LCIC in each of the EDA sampling areas and comparison areas. The vertical axis of each histogram represents the relative frequency of each concentration range represented on the horizontal axis. The highest bar represents the most commonly found concentration range. Gaps in the horizontal axis indicate that no concentrations were observed in that range. Non-detectable concentrations are coded as zero in these figures.

Box Plots. An example of a box plot is shown in Figure 6-7. The vertical axis is the concentration of an LCIC in ppb. The box includes the middle 50 percent of the data. The line in the box marks the median, or 50th

Table 6-7a

SUMMARY OF ANALYTICAL RESULTS FOR 1,2-DICHLOROBENZENE (DCB)

			Concentration (ppb)			
Sampling Area	Number of Good Results[a]	Percent Detects	Minimum (Includes NDs[b])	Minimum (NDs not Included)	Maximum	Median (Includes NDs)
1	39	100	0.20	0.20	5.65	1.01
2	68	98	ND	0.13	19.80	0.39
3	73	99	ND	0.12	2.37	0.40
4	60	95	ND	0.13	2.23	0.36
5	80	100	0.14	0.14	3.19	0.39
6	84	100	0.16	0.16	1.51	0.36
7	86	99	ND	0.16	0.94	0.40
Census Tract 221	50	100	0.19	0.19	1.15	0.39
Census Tract 225	58	100	0.18	0.18	1.40	0.43
Tonawanda and Cheektowaga	57	100	0.11	0.11	1.38	0.36
TOTAL	655					

---

[a] "Good Results" are those that passed all QC criteria.

[b] ND = non-detect.

Table 6-7b

SUMMARY OF ANALYTICAL RESULTS FOR 1,2,4-TRICHLOROBENZENE (TCB)

Sampling Area	Number of Good Results[a]	Percent Detects	Concentration (ppb) Minimum (Includes NDs[b])	Concentration (ppb) Minimum (NDs not Included)	Concentration (ppb) Maximum	Concentration (ppb) Median (Includes NDs)
1	40	100	0.15	0.15	45.11	8.67
2	73	100	0.17	0.17	167.33	0.91
3	82	100	0.08	0.08	7.65	0.89
4	61	98	ND	0.11	12.08	0.43
5	80	100	0.08	0.08	35.65	0.52
6	88	100	0.04	0.04	3.51	0.37
7	88	100	0.15	0.15	4.49	0.58
Census Tract 221	53	100	0.25	0.25	3.12	0.65
Census Tract 225	60	100	0.12	0.12	33.07	0.60
Tonawanda and Cheektowaga	60	100	0.07	0.07	0.92	0.14
TOTAL	685					

---

[a] "Good Results" are those that passed all QC criteria.
[b] ND = non-detect.

Table 6-7c

SUMMARY OF ANALYTICAL RESULTS FOR 1,2,3,4-TETRACHLOROBENZENE (TeCB)

Sampling Area	Number of Good Results[a]	Percent Detects	Concentration (ppb) Minimum (Includes NDs[b])	Minimum (NDs not Included)	Maximum	Median (Includes NDs)
1	37	100	0.11	0.11	67.20	11.48
2	72	100	0.23	0.23	66.66	1.16
3	82	99	ND	0.10	9.55	1.06
4	60	98	ND	0.04	182.41	0.38
5	78	99	ND	0.09	168.64	0.43
6	87	98	ND	0.04	2.90	0.31
7	88	100	0.10	0.10	3.91	0.54
Census Tract 221	52	100	0.22	0.22	1.33	0.53
Census Tract 225	59	100	0.06	0.06	64.25	0.61
Tonawanda and Cheektowaga	61	79	ND	0.02	0.84	0.05
TOTAL	676					

---

[a] "Good Results" are those that passed all QC criteria.
[b] ND = non-detect.

Table 6-7d

SUMMARY OF ANALYTICAL RESULTS FOR 2-CHLORONAPHTHALENE (CNP)

Sampling Area	Number of Good Results[a]	Percent Detects	Concentration (ppb)			
			Minimum (includes NDs[b])	Minimum (NDs not included)	Maximum	Median (includes NDs)
1	36	44	ND	0.06	0.21	ND
2	70	61	ND	0.01	0.24	0.04
3	75	51	ND	0.04	0.15	0.04
4	52	62	ND	0.02	0.13	0.04
5	72	67	ND	0.02	0.16	0.06
6	88	65	ND	0.02	0.19	0.06
7	82	70	ND	0.02	0.18	0.06
Census Tract 221	51	67	ND	0.03	0.22	0.06
Census Tract 225	60	72	ND	0.04	0.32	0.07
Tonawanda and Cheektowaga	54	57	ND	0.01	0.21	0.03
TOTAL	640					

---

[a] "Good Results" are those that passed all QC criteria.

[b] ND = non-detect.

Table 6-7e

SUMMARY OF ANALYTICAL RESULTS FOR ALPHA-BHC (A-BHC)

Sampling Area	Number of Good Results[a]	Percent Detects	Concentration (ppb) Minimum (Includes NDs[b])	Minimum (NDs not Included)	Maximum	Median (Includes NDs)
1	39	97	ND	0.66	69.70	8.25
2	73	86	ND	0.06	100.31	0.40
3	81	76	ND	0.01	16.05	0.22
4	61	70	ND	0.03	152.53	0.12
5	80	64	ND	0.03	83.51	0.14
6	88	61	ND	0.03	1.99	0.07
7	89	78	ND	0.02	2.42	0.14
Census Tract 221	53	79	ND	0.06	1.19	0.18
Census Tract 225	60	65	ND	0.02	33.97	0.10
Tonawanda and Cheektowaga	61	5	ND	0.01	0.17	ND
TOTAL	685					

---

[a] "Good Results" are those that passed all QC criteria.

[b] ND = non-detect.

Table 6-7f

SUMMARY OF ANALYTICAL RESULTS FOR DELTA-BHC (D-BHC)

Sampling Area	Number of Good Results[a]	Percent Detects	Concentration (ppb) Minimum (Includes NDs[b])	Minimum (NDs not Included)	Maximum	Median (Includes NDs)
1	39	69	ND	0.28	38.83	1.13
2	72	51	ND	0.03	2.33	0.04
3	79	30	ND	0.05	79.99	ND
4	61	20	ND	0.08	3.04	ND
5	80	22	ND	0.03	9.96	ND
6	84	11	ND	0.03	3.44	ND
7	86	14	ND	0.05	1.25	ND
Census Tract 221	52	8	ND	0.04	0.94	ND
Census Tract 225	59	15	ND	0.07	5.40	ND
Tonawanda and Cheektowaga	61	0	ND	ND	ND	ND
TOTAL	673					

---

[a] "Good Results" are those that passed all QC criteria.

[b] ND = non-detect.

Table 6-7g

SUMMARY OF ANALYTICAL RESULTS FOR BETA-BHC (B-BHC)

Sampling Area	Number of Good Results[a]	Percent Detects	Concentration (ppb)			
			Minimum (Includes NDs[b])	Minimum (NDs not Included)	Maximum	Median (Includes NDs)
1	39	97	ND	1.89	101.72	11.58
2	70	64	ND	0.07	29.97	0.20
3	77	54	ND	0.06	51.17	0.13
4	56	48	ND	0.03	4,108.31	ND
5	77	32	ND	0.01	663.49	ND
6	79	21	ND	0.10	3.15	ND
7	74	45	ND	0.05	2.01	ND
Census Tract 221	49	29	ND	0.07	1.03	ND
Census Tract 225	54	46	ND	0.01	50.57	ND
Tonawanda and Cheektowaga	59	3	ND	0.36	5.36	ND
TOTAL	634					

---

[a] "Good Results" are those that passed all QC criteria.

[b] ND = non-detect.

Table 6-7h

SUMMARY OF ANALYTICAL RESULTS FOR GAMMA-BHC (G-BHC)

Sampling Area	Number of Good Results[a]	Percent Detects	Concentration (ppb)			
			Minimum (includes NDs[b])	Minimum (NDs not included)	Maximum	Median (includes NDs)
1	40	85	ND	0.36	20.99	1.72
2	72	56	ND	0.03	6.67	0.08
3	80	45	ND	0.01	12.68	ND
4	60	33	ND	0.03	85.60	ND
5	80	26	ND	0.04	26.33	ND
6	88	17	ND	0.04	0.89	ND
7	89	24	ND	0.04	0.61	ND
Census Tract 221	53	17	ND	0.04	80.81	ND
Census Tract 225	60	30	ND	0.03	15.83	ND
Tonawanda and Cheektowaga	59	2	ND	0.04	0.04	ND
TOTAL	681					

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[a] "Good Results" are those that passed all QC criteria.

[b] ND = non-detect.

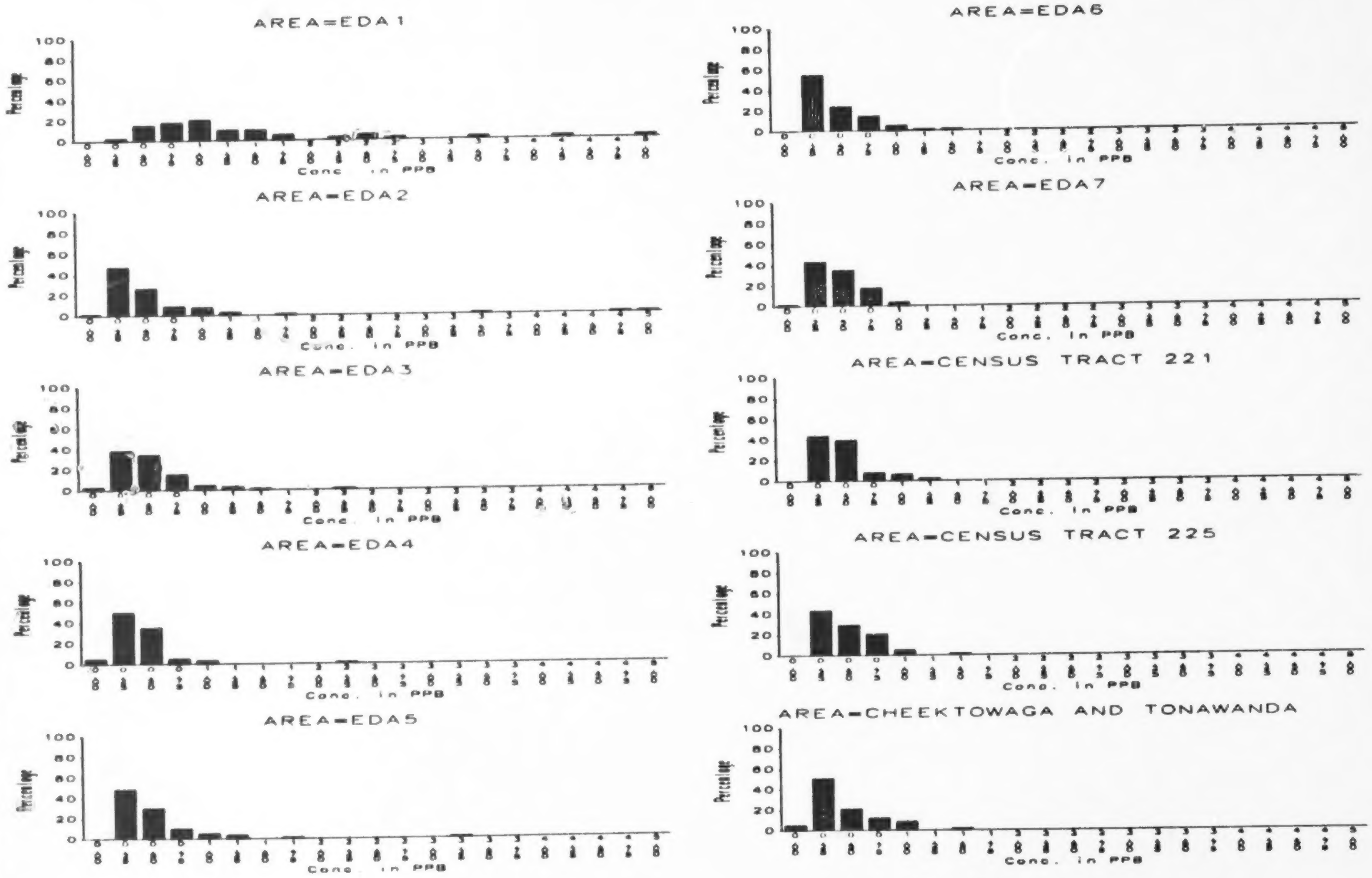


Figure 6-6a

1, 2-DICHLOROBENZENE

SOIL ASSESSMENT — INDICATOR CHEMICALS CONCENTRATIONS BY AREA

Reproduced from best available copy.

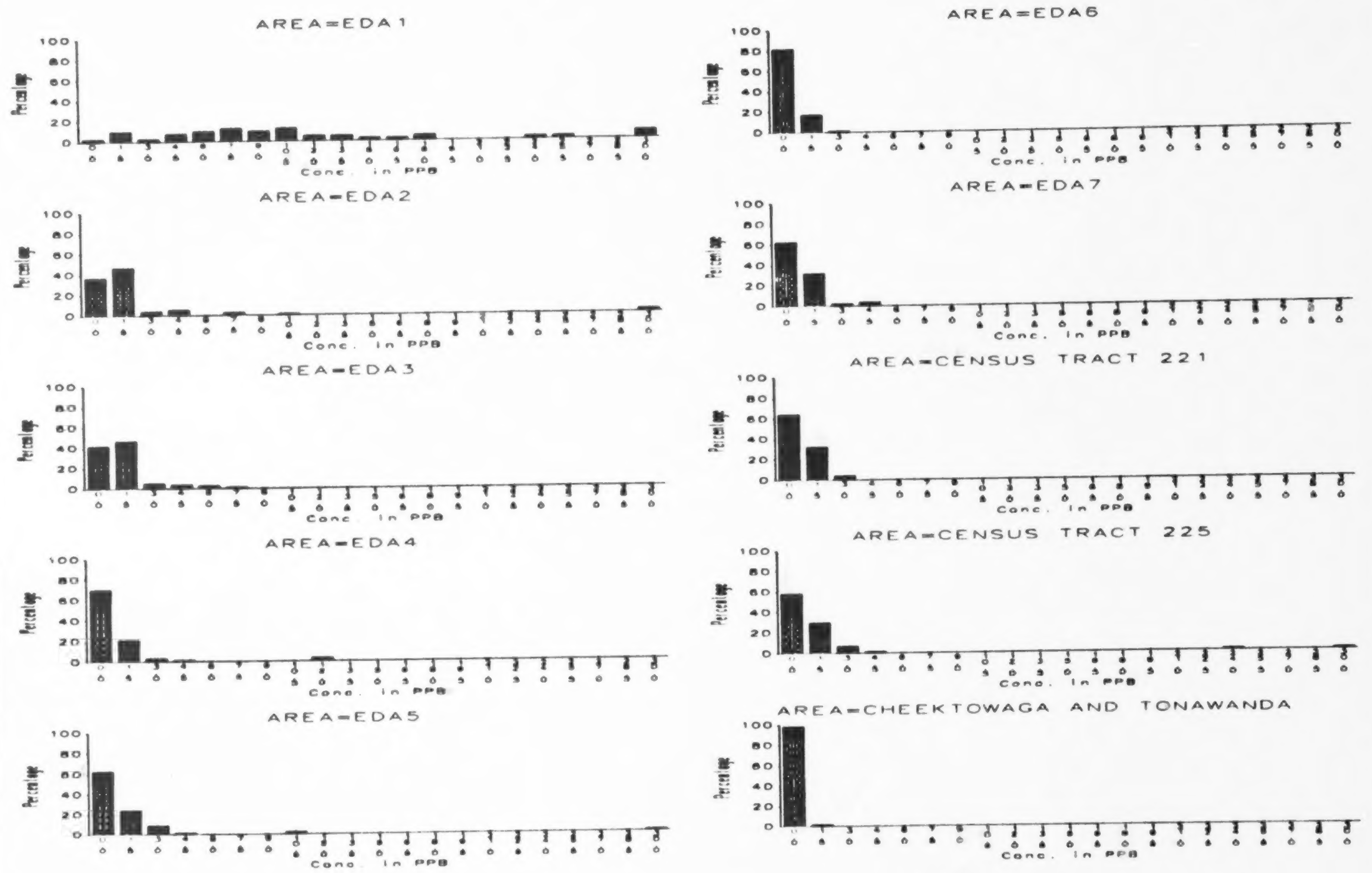


Figure 6-6b

1, 2, 4-TRICHLOROBENZENE

SOIL ASSESSMENT — INDICATOR CHEMICALS CONCENTRATIONS BY AREA

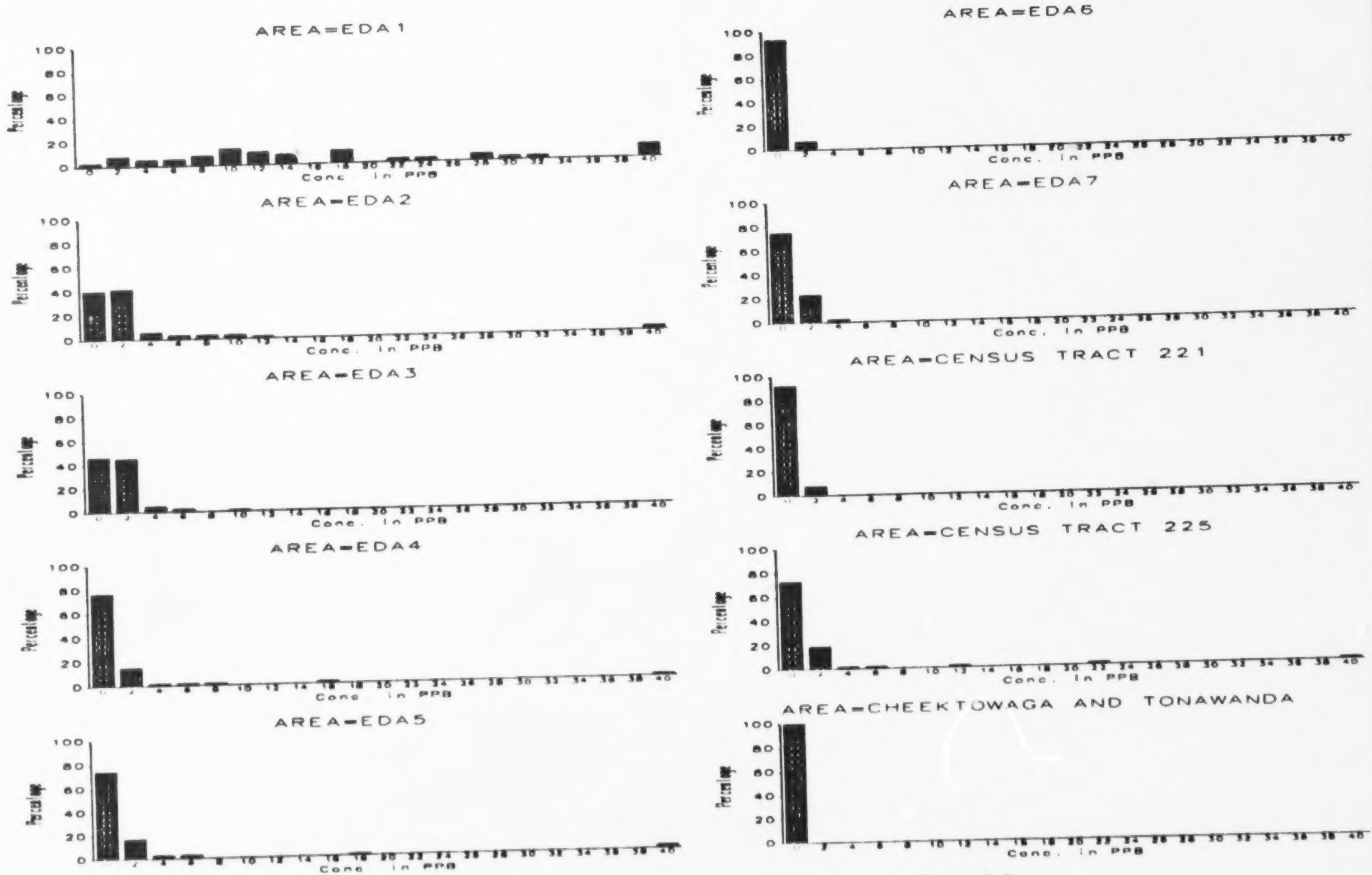


Figure 6-6c
1, 2, 3, 4-TETRACHLOROBENZENE
SOIL ASSESSMENT — INDICATOR CHEMICALS
CONCENTRATIONS BY AREA

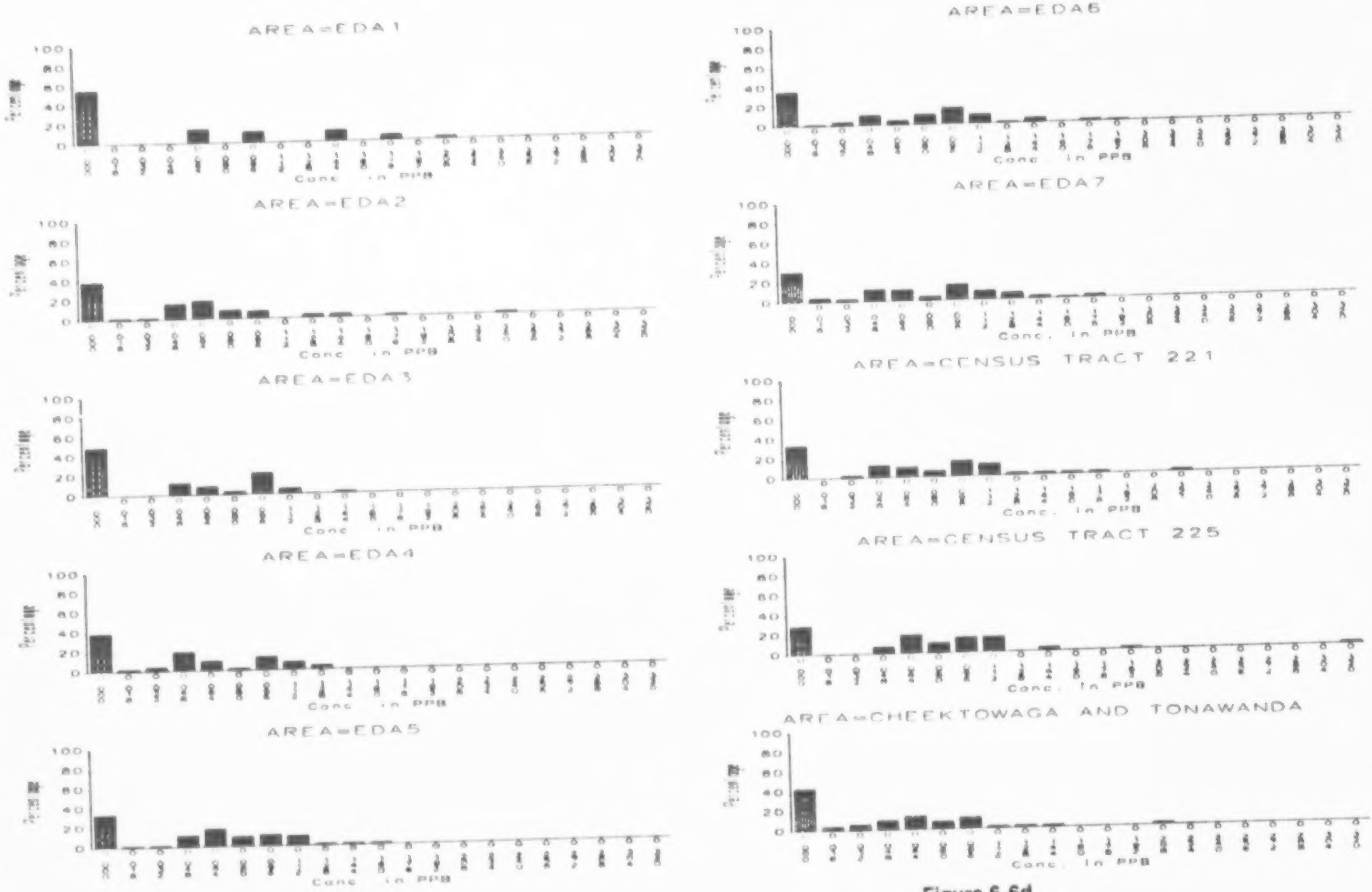


Figure 6-6d
2-CHLORONAPHTHALENE
SOIL ASSESSMENT — INDICATOR CHEMICALS
CONCENTRATIONS BY AREA

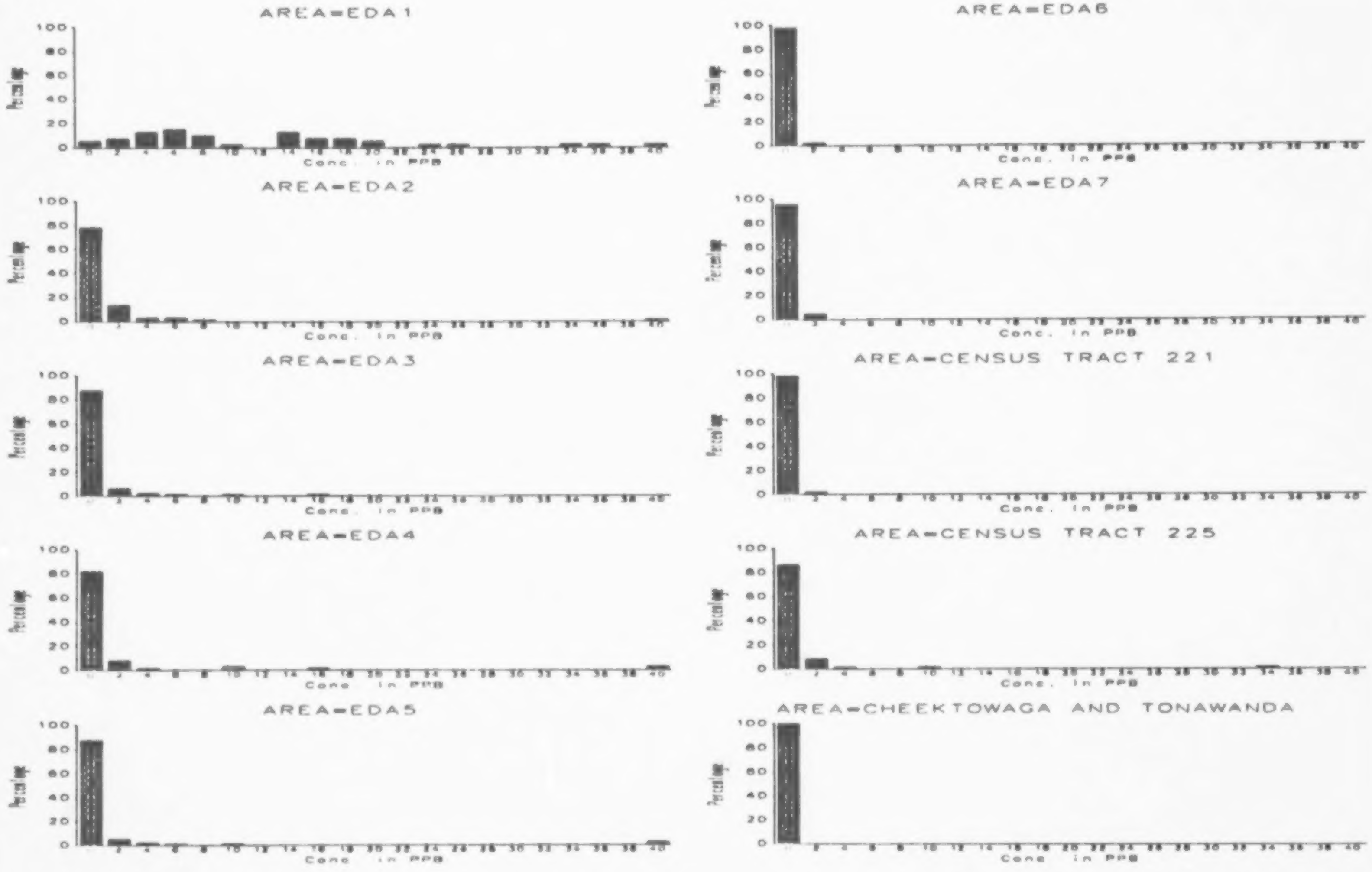


Figure 6-6e
ALPHA-BHC
SOIL ASSESSMENT — INDICATOR CHEMICALS
CONCENTRATIONS BY AREA

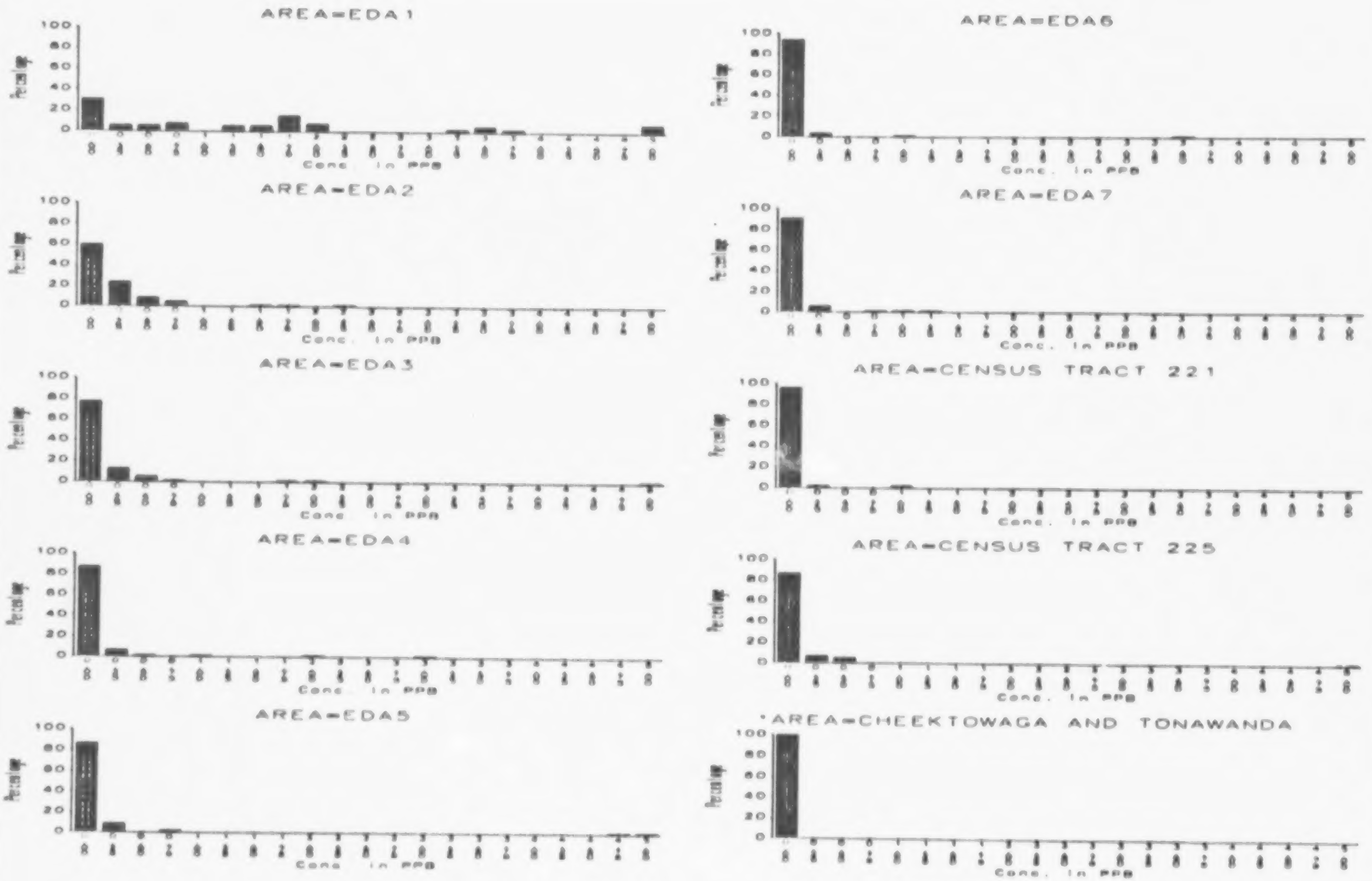


Figure 6-6f
DELTA-BHC
SOIL ASSESSMENT — INDICATOR CHEMICALS
CONCENTRATIONS BY AREA

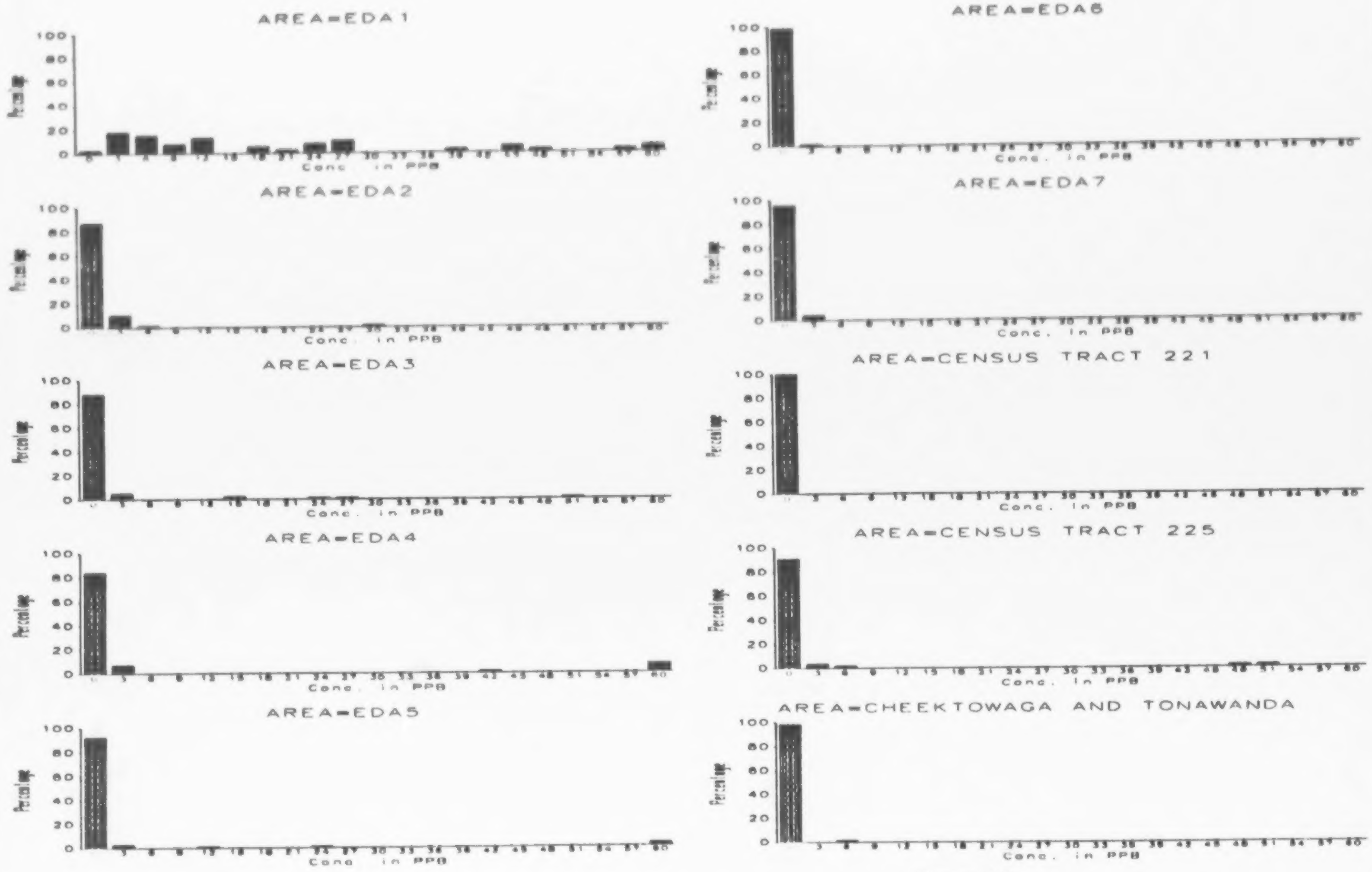


Figure 6-6g
BETA-BHC
SOIL ASSESSMENT — INDICATOR CHEMICALS
CONCENTRATIONS BY AREA

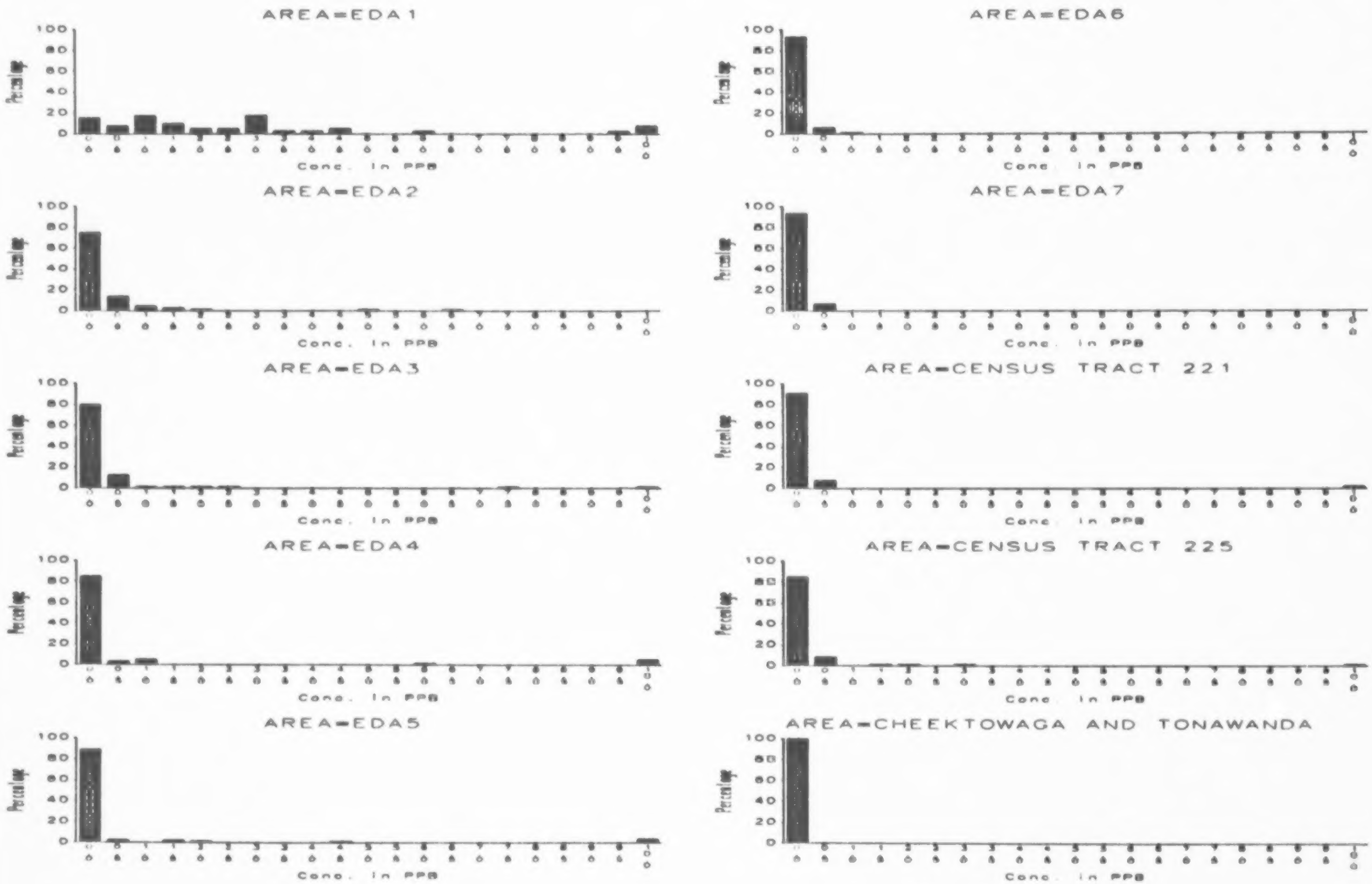


Figure 6-6h
GAMMA-BHC
SOIL ASSESSMENT — INDICATOR CHEMICALS CONCENTRATIONS BY AREA

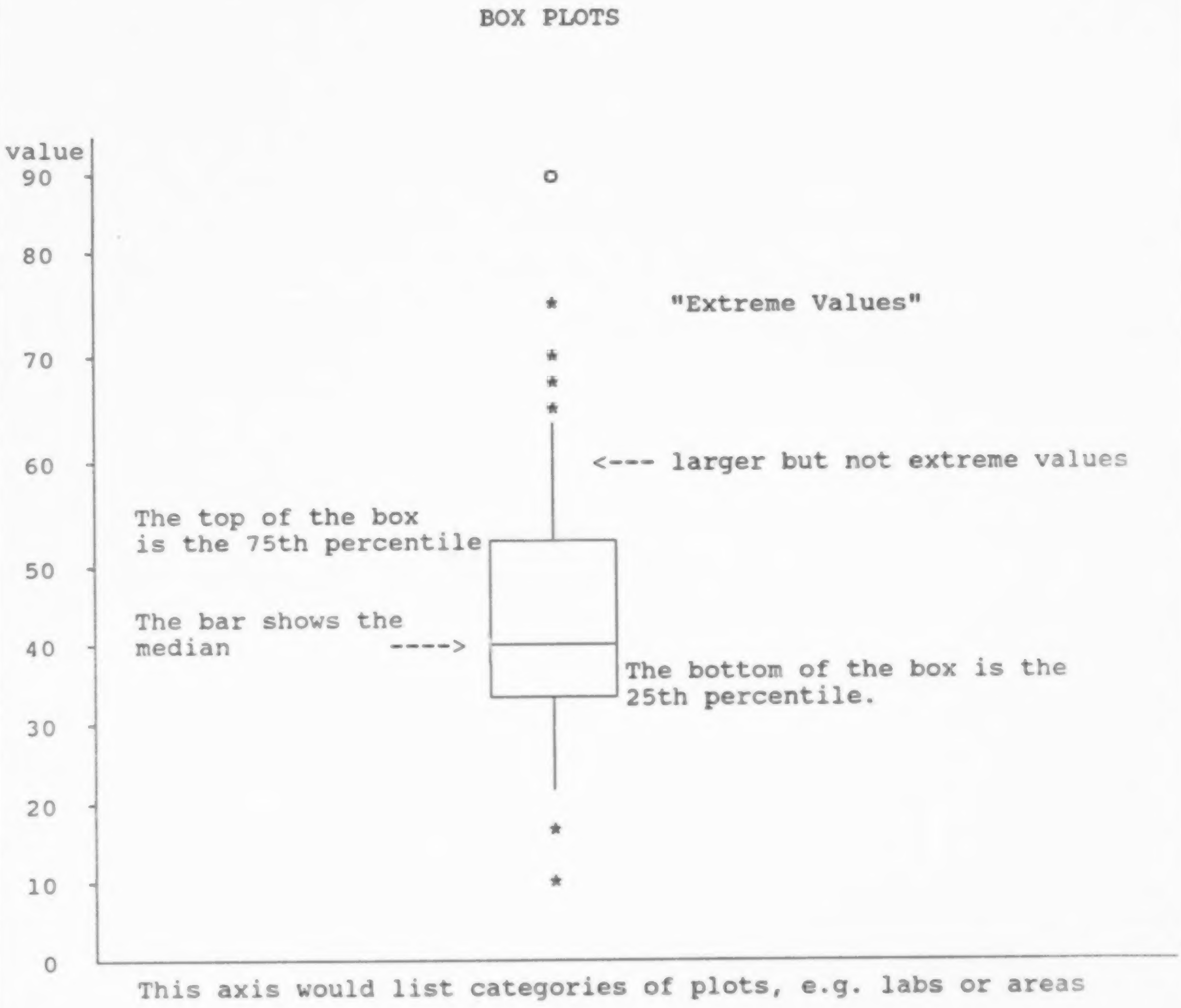


Figure 6-7
SOIL ASSESSMENT — INDICATOR CHEMICALS
BOX PLOT EXAMPLE

percentile; 25 percent of the concentrations are included in the part of the box above the median line, and 25 percent are in the part of the box below the median line.

The upper "whisker" (vertical line above the box) extends to the largest non-extreme value (the interpretation of "extreme" is based on a relationship with the normal [Gaussian] distribution). The extreme values are plotted with asterisks and the more extreme with circles. Those extreme values that lie off the scale are printed at the top of the figure.

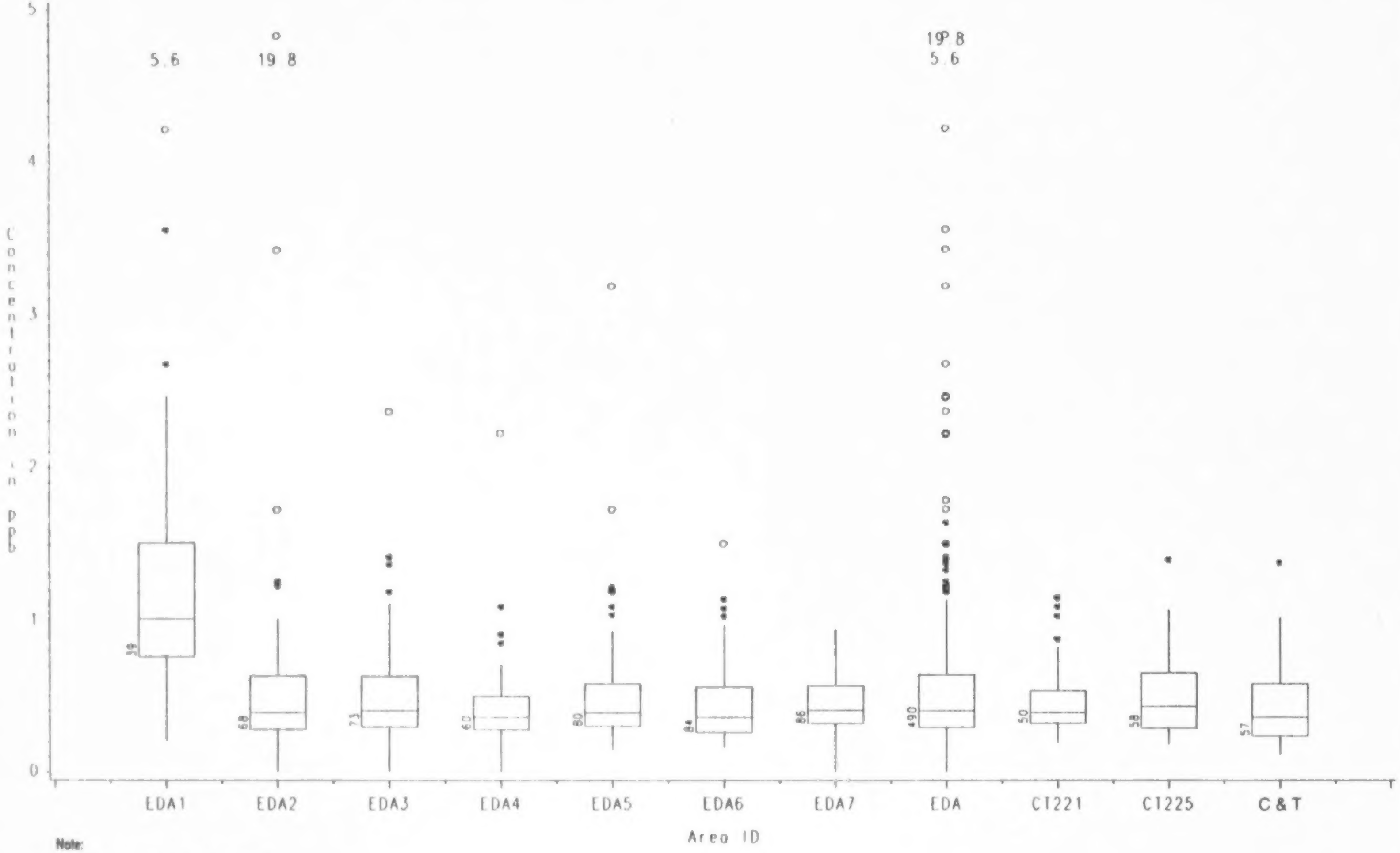
Figures 6-8a to 6-8h present the results of total EDA, EDA sampling areas, and comparison areas using box plots. The "boxes" in these plots are reduced to lines when more than 75 percent of the data is non-detect. In these plots, non-detect concentrations are coded with a value of zero.

6.4 STATISTICAL COMPARISONS OF SAMPLED AREAS

This section gives the results of applying the statistical techniques described in Section 5.5, Statistical Analysis, and Appendix B to the soil concentration data. One of the objectives of the study was to produce precise data of known quality suitable for making reliable comparisons between EDA sampling areas and comparison areas. Therefore, the statistical comparisons reported upon in this section use only the Good data (observations) as described in Section 6.2 of this report. There is no evidence that the usability of the data is related to sampling area or concentration in any way that would bias the comparisons.

Because the design of the sampling program explicitly randomized certain external factors, statistical inferences for other data groupings would require analysis to check that an unbiased allocation of factors occurred for the new groupings. If such an allocation were lacking, the external factors not randomized could bias the comparison results.

The statistical method outlined in Section 5.5, based on the Wilcoxon rank-sum test, was applied to the data described in Section 6.3. Statistical comparisons were made, first, between the seven EDA sampling areas and the three comparison areas, and second, among the three comparison areas. Table 6-8 shows these comparisons for each LCIC (univariate comparisons),

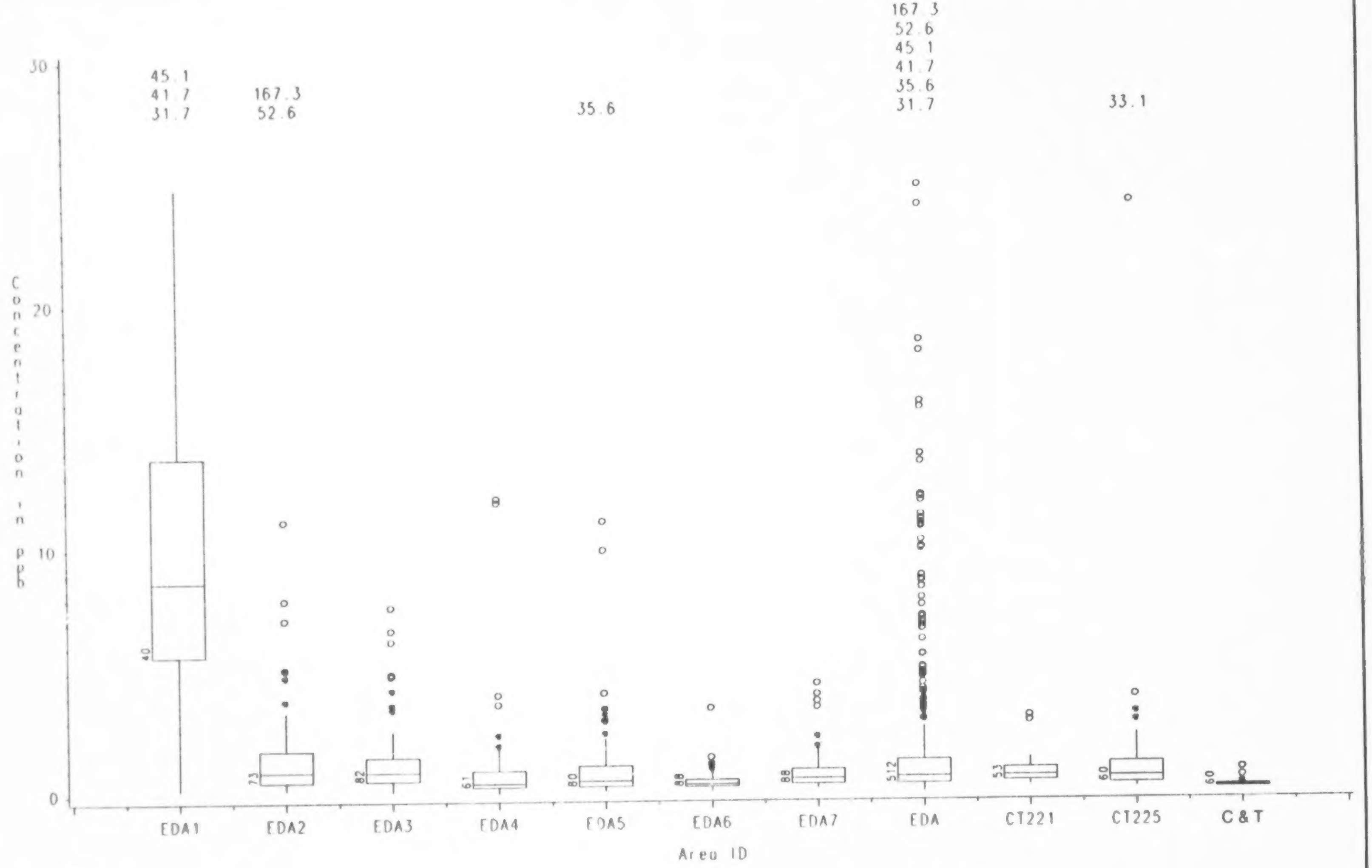


Note:

EDA (Column 8) = Composite of Columns
1 through 7

C & T = Cheektowaga and Tonawanda

Figure 6-8a
LCIC = 1, 2-DICHLOROBENZENE
SOIL ASSESSMENT — INDICATOR CHEMICALS
CONCENTRATIONS BY SAMPLED AREAS



Note:

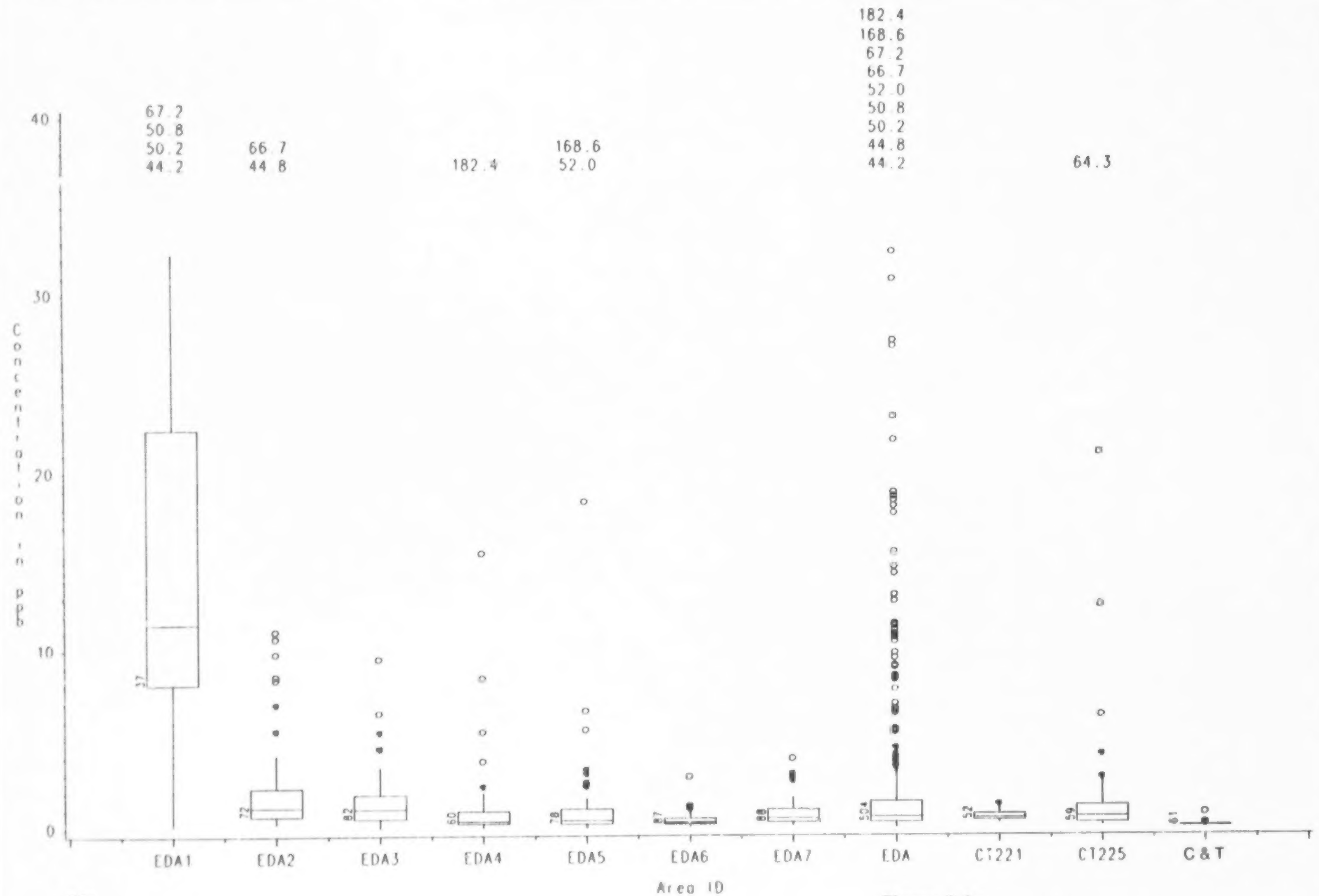
EDA (Column 8) = Composite of Columns 1 through 7

C & T = Cheektowaga and Tonawanda

Figure 6-8b

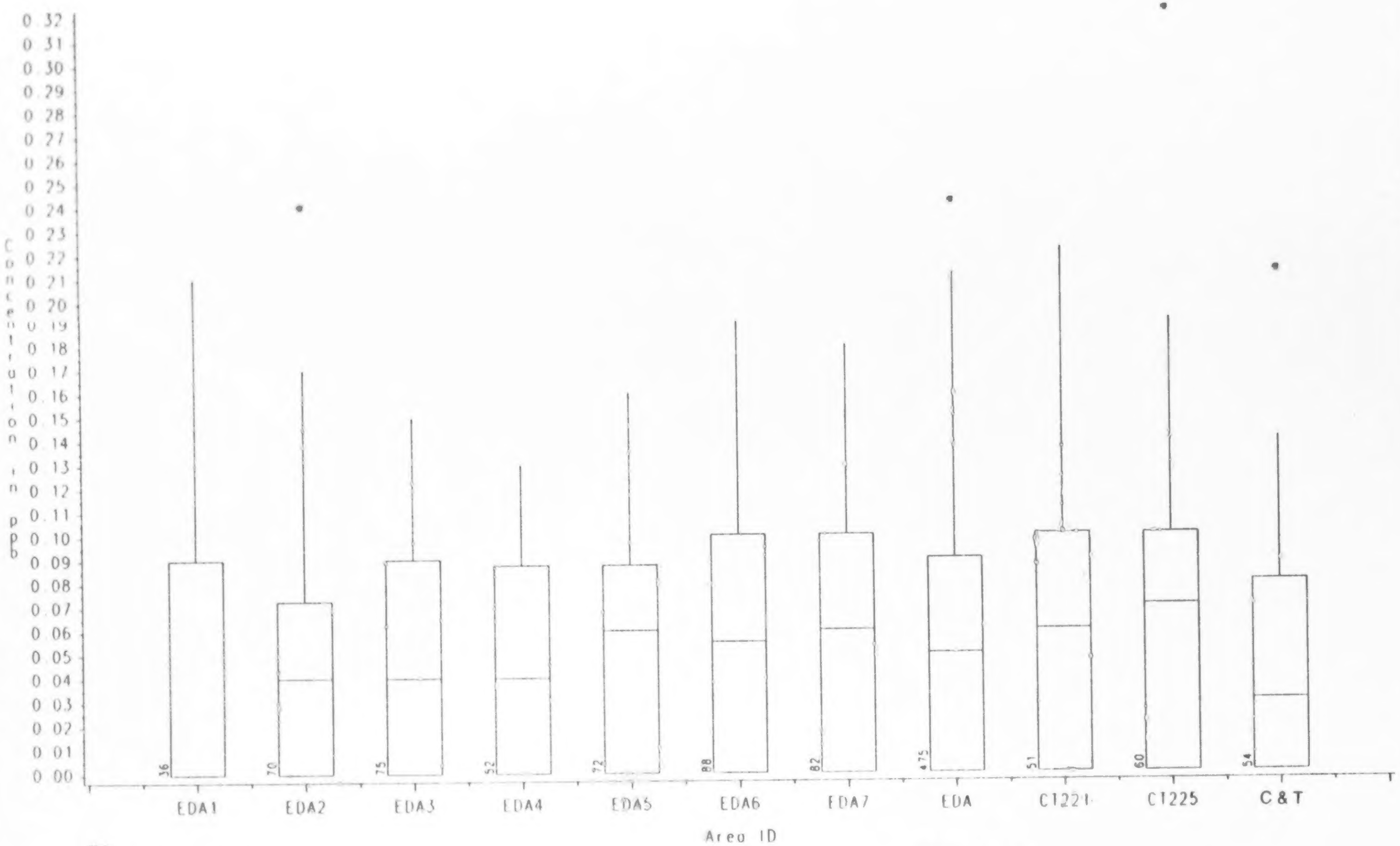
LCIC = 1, 2, 4-TRICHLOROBENZENE

SOIL ASSESSMENT — INDICATOR CHEMICALS CONCENTRATIONS BY SAMPLED AREAS



Note:
EDA (Column 8) = Composite of Columns 1 through 7
C & T = Cheektowaga and Tonawanda

Figure 6-8c
LCIC = 1, 2, 3, 4-TETRACHLOROBENZENE
SOIL ASSESSMENT — INDICATOR CHEMICALS
CONCENTRATIONS BY SAMPLED AREAS



Note:

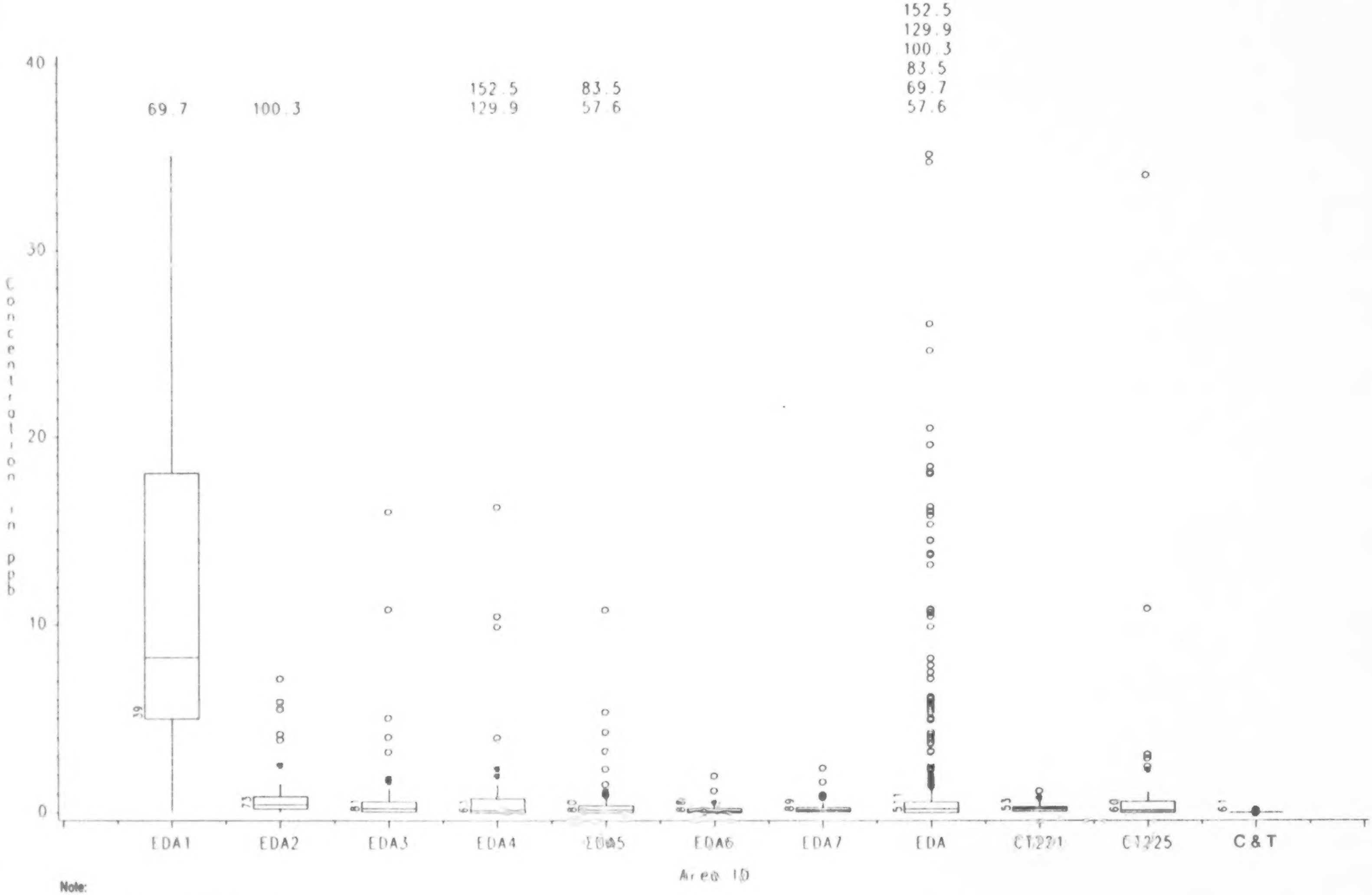
EDA (Column 8) = Composite of Columns 1 through 7

C & T = Cheektowaga and Tonawanda

Figure 6-8d

LCIC = 2-CHLORONAPHTHALENE

SOIL ASSESSMENT — INDICATOR CHEMICALS CONCENTRATIONS BY SAMPLED AREAS

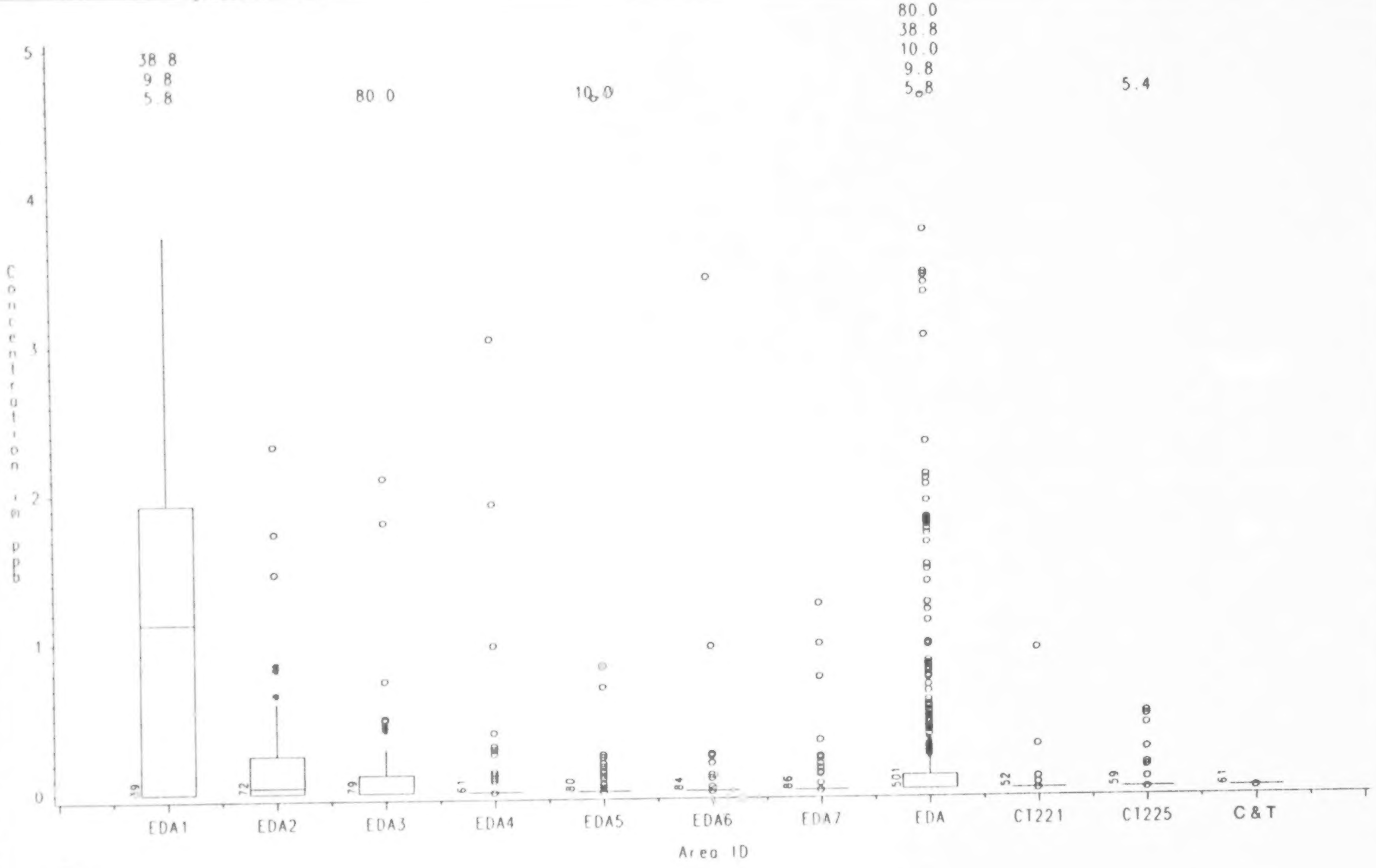


Note:

EDA (Column 8) = Composite of Columns 1 through 7

C & T = Cheektowaga and Tonawanda

Figure 6-8e
LCIC = ALPHA-BHC
SOIL ASSESSMENT — INDICATOR CHEMICALS
CONCENTRATIONS BY SAMPLED AREAS

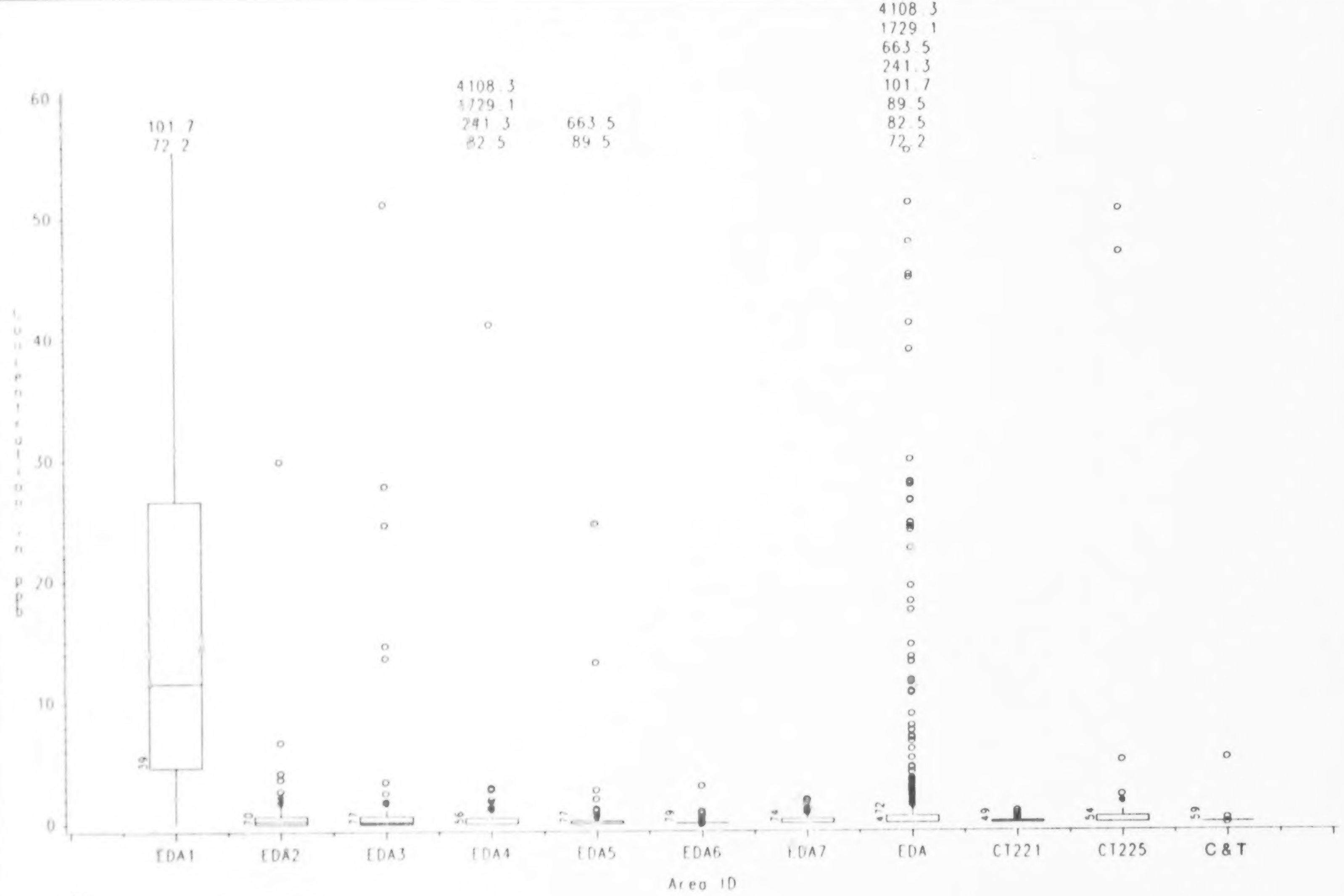


Note:

EDA (Column 8) = Composite of Columns 1 through 7

C & T = Cheektowaga and Tonawanda

Figure 6-8f
LCIC = DELTA-BHC
SOIL ASSESSMENT — INDICATOR CHEMICALS
CONCENTRATIONS BY SAMPLED AREAS



Note:

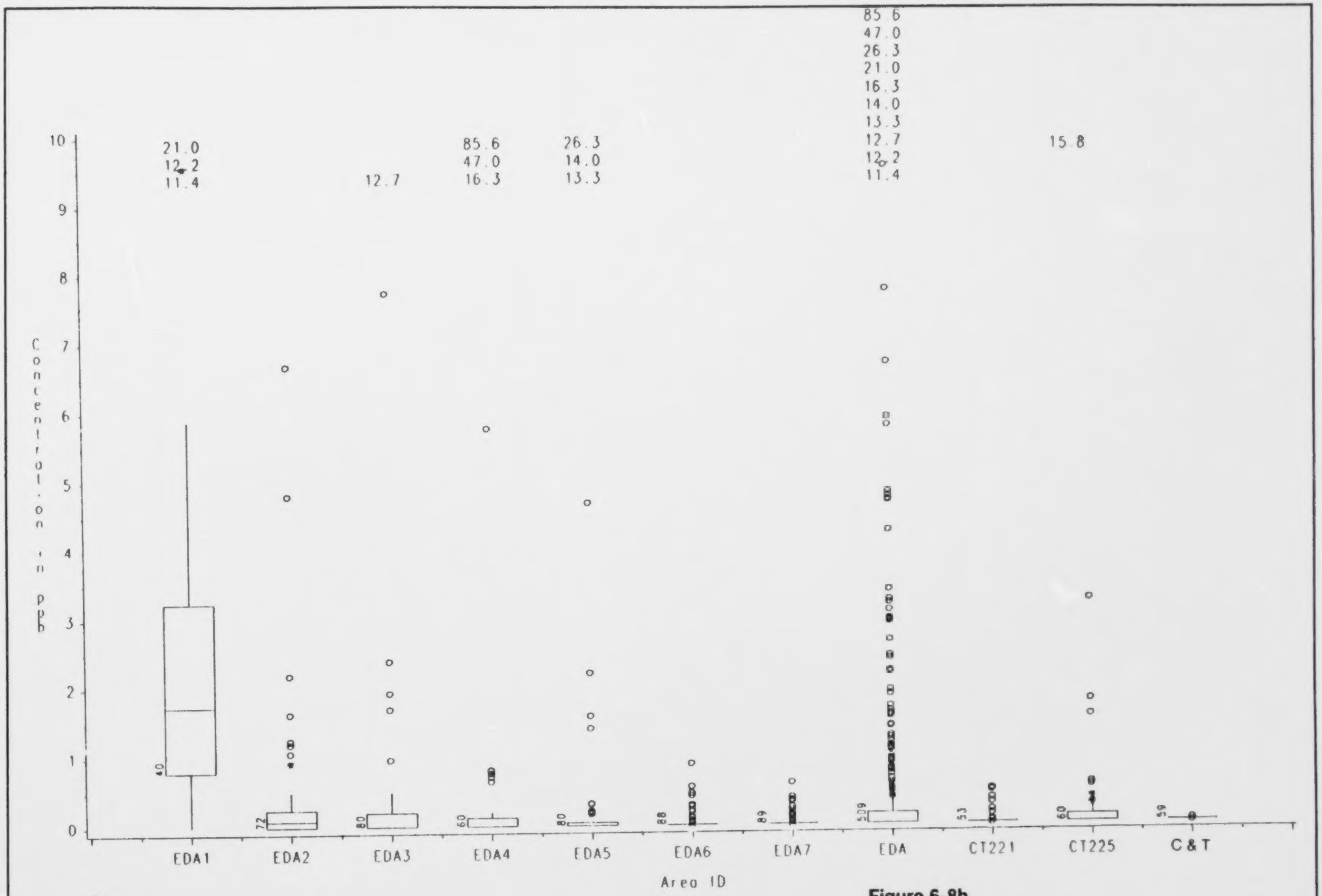
EDA (Column 8) = Composite of Columns 1 through 7

C & T = Cheektowaga and Tonawanda

Figure 6-8g

LCIC = BETA-BHC

SOIL ASSESSMENT — INDICATOR CHEMICALS CONCENTRATIONS BY SAMPLED AREAS



Note:

EDA (Column 8) = Composite of Columns 1 through 7

C & T = Cheektowaga and Tonawanda

Figure 6-8h

LCIC = GAMMA-BHC

SOIL ASSESSMENT — INDICATOR CHEMICALS CONCENTRATIONS BY SAMPLED AREAS

Table 6-8

RESULTS OF NONPARAMETRIC UNIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD[a,b,c]

		Median	EDA Sampling Areas							Comparison Areas		
LCIC	Comparison Area	Conc. (ppb)	1	2	3	4	5	6	7	221	225	C&T
			1.01	0.39	0.40	0.36	0.39	0.36	0.41	0.39	0.43	0.36
1,2-dichlorobenzene	221	0.39	++	o	o	--	o	--	o		o	--
	225	0.43	++	o	o	-	o	o	o	o		o
	C&T[d]	0.36	++	++	++	o	o	o	+	++	o	
			8.67	0.91	0.89	0.43	0.52	0.37	0.58	0.65	0.60	0.13
1,2,4-trichlorobenzene	221	0.65	++	++	+	-	o	--	o		o	--
	225	0.60	++	++	+	o	o	--	o	o		--
	C&T	0.13	++	++	++	++	++	++	++	++	++	
			11.48	1.17	1.06	0.38	0.43	0.31	0.54	0.53	0.61	0.05
1,2,3,4-tetrachlorobenzene	221	0.53	++	++	++	-	o	--	o		o	--
	225	0.61	++	++	++	o	o	--	o	o		--
	C&T	0.05	++	++	++	++	++	++	++	++	++	
			ND	0.04	0.04	0.04	0.06	0.05	0.06	0.06	0.07	0.03
2-chloronaphthalene	221	0.06	o	o	o	o	o	o	o		o	o
	225	0.07	-	-	--	o	-	o	o	o		-
	C&T	0.03	o	o	o	o	o	o	+	o	+	
			8.25	0.40	0.22	0.12	0.13	0.07	0.14	0.18	0.11	ND
alpha-BHC	221	0.18	++	++	o	o	o	-	o		o	--
	225	0.11	++	++	o	o	o	o	o	o		--
	C&T	ND	++	++	++	++	++	++	++	++	++	

---

a. ++: EDA > Comparison area at 0.01 significance level
+: EDA > Comparison area at 0.05 significance level
o: No significant difference at 0.05 significance level
-: EDA < Comparison area at 0.05 significance level
--: EDA < Comparison area at 0.01 significance level

b. All test results reported are based on two-sided p-values.

c. The first entry in each column is median concentration. ND indicates non-detect.

d. C&T = Cheektowaga and Tonawanda

Table 6-8
(continued)

LCIC	Comparison Area	Median Conc. (ppb)	EDA Sampling Areas 1	2	3	4	5	6	7	Comparison Areas 221	225	C&T
			1.13	0.04	ND	ND	ND	ND	ND	ND	ND	ND
delta-BHC	221	ND	++	++	++	+	+	o	o		o	o
	225	ND	++	++	o	o	o	o	o	o		--
	C&T	ND	++	++	++	++	++	++	++	o	++	
			11.58	0.20	0.13	ND	ND	ND	ND	ND	ND	ND
beta-BHC	221	ND	++	++	++	+	o	o	o		+	--
	225	ND	++	o	o	o	o	--	o	-		--
	C&T	ND	++	++	++	++	++	++	++	++	++	
			1.73	0.09	ND	ND	ND	ND	ND	ND	ND	ND
gamma-BHC	221	ND	++	++	++	+	o	o	o		o	--
	225	ND	++	+	o	o	o	-	o	o		--
	C&T	ND	++	++	++	++	++	++	++	++	++	
TOTALS	++		21	17	12	6	6	6	6	6	6	0
	+		0	1	2	3	1	0	2	0	2	0
	o		2	5	9	11	16	10	16	9	8	3
	-		1	1	0	3	1	2	0	1	0	1
	--		0	0	1	1	0	6	0	0	0	12
All Symbols			24	24	24	24	24	24	24	16	16	16

and Table 6-9 shows the comparisons for the LCICs as a group (multivariate comparisons). Table 6-10 provides a summary of the number of univariate comparisons that were significant. (Tables of the actual "P" values are in Appendix K.)

Five symbols are shown in the following tables: ++, +, o, -, and --. The ++ symbol indicates that the concentration of an LCIC (or the grouped LCICs) is significantly higher than in the comparison area at the 0.01 significance level (two-sided); the + symbol shows significance at the 0.05 level (two-sided); o indicates no significant difference at the 0.01 or 0.05 level; - indicates that the LCIC (or grouped LCICs) concentration in the EDA is significantly lower than in the comparison area at the 0.05 level; and -- indicates significantly lower at the 0.01 level. (A 0.01 significance level means that there is a 1-in-100 chance that a difference as large as that observed could occur by chance alone. The 0.05 significance level corresponds to a 1-in-20 chance.) The median concentration values are also given to show the magnitude of the concentrations being compared.

Figure 6-9 graphically displays the results of these comparisons between the EDA sampling areas and the comparison areas for each LCIC; Figure 6-10 shows the results for the LCICs as a group; and Figure 6-11 shows the results for the comparison area analyses. In these figures, the "up" arrows represent LCIC concentrations that are significantly higher at the 0.05 level (two-sided) than those in the comparison area, while the "down" arrows represent LCIC concentrations that are significantly lower than comparison area concentrations.

Some additional comments are needed with respect to Tables 6-8 to 6-10. No attempt was made to adjust the tables for two possible effects that would influence the comparison results. The first effect is the number of "false positive" results arising from conducting a large number of comparisons. The significance level represents the probability that the null hypothesis (no difference between two sampling areas) would be rejected even if there were in fact no true difference. (In other words, the probability that the comparison could mistakenly find a difference between two areas.) When many tests are conducted, some rejections of the null hypothesis are expected to occur by chance ("false positives"). This effect can be corrected under certain assumptions, but there is no universally valid method of making such a correction.

Table 6-9

RESULTS OF NONPARAMETRIC MULTIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD[a,b]

Comparison Area	EDA Sampling Areas							Comparison Areas		
	1	2	3	4	5	6	7	221	225	C&T
221	++	++	++	--	+	--	++		+	--
225	++	++	+	o	-	-	o	-		--
C&T[c]	++	++	++	++	++	++	++	++	++	

---

a. ++: EDA > Comparison area at 0.01 significance level
+: EDA > Comparison area at 0.05 significance level
o: No significant difference at 0.05 significance level
-: EDA < Comparison area at 0.05 significance level
--: EDA < Comparison area at 0.01 significance level

b. The direction of the difference between the EDA and Comparison Areas is based on the sign of the sum of the elements of the 8 X 1 vector of rank-sums (Appendix B)

c. C&T = Cheektowaga and Tonawanda

Table 6-10

SUMMARY OF NONPARAMETRIC UNIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD[a, b]

Totals over all LCICs

Comparison Area		EDA Sampling Areas							Comparison Areas		
		1	2	3	4	5	6	7	221	225	C&T
CT221	++	7	6	4	0	0	0	0		0	0
	+	0	0	1	3	1	0	0		1	0
	o	1	2	3	2	7	4	8		7	2
	-	0	0	0	2	0	1	0		0	0
	--	0	0	0	1	0	3	0		0	6
CT225	++	7	4	1	0	0	0	0	0		0
	+	0	1	1	0	0	0	0	0		0
	o	0	2	5	7	7	4	8	7		1
	-	1	1	0	1	1	1	0	1		1
	--	0	0	1	0	0	3	0	0		6
C&T[c]	++	7	7	7	6	6	6	6	6	6	
	+	0	0	0	0	0	0	2	0	1	
	o	1	1	1	2	2	2	0	2	1	
	-	0	0	0	0	0	0	0	0	0	
	--	0	0	0	0	0	0	0	0	0	

---

a. ++: EDA > Comparison area at 0.01 significance level
+: EDA > Comparison area at 0.05 significance level
o: No significant difference at 0.05 significance level
-: EDA < Comparison area at 0.05 significance level
--: EDA < Comparison area at 0.01 significance level

b. All test results reported are based on two-sided p-values.

c. C&T = Cheektowaga and Tonawanda

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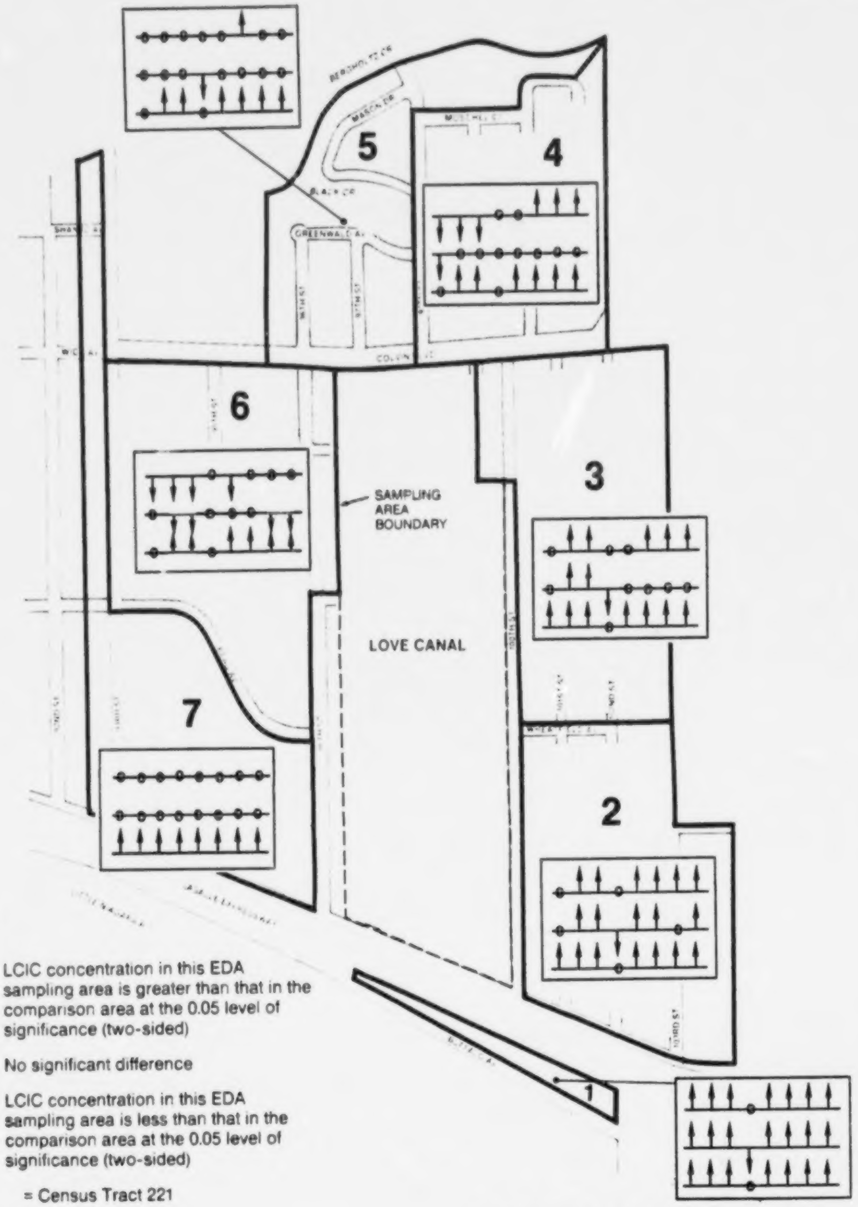


LEGEND:

↑ LCIC concentration in this EDA sampling area is greater than that in the comparison area at the 0.05 level of significance (two-sided)

○ No significant difference

↓ LCIC concentration in this EDA sampling area is less than that in the comparison area at the 0.05 level of significance (two-sided)

Top Line = Census Tract 221

Middle Line = Census Tract 225

Bottom Line = Cheektowaga and Tonawanda

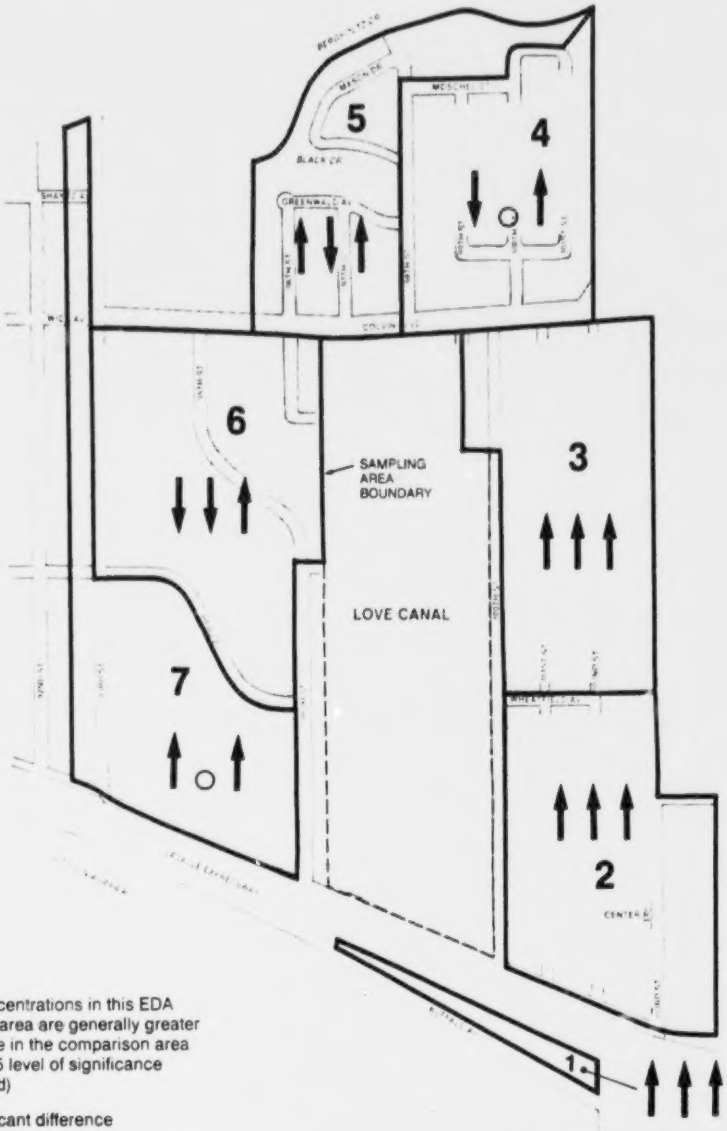
LCICs are in the following order on the line:

1,2-Dichlorobenzene
1,2,4-Trichlorobenzene
1,2,3,4-Tetrachlorobenzene
2-Chloronaphthalene
Alpha-BHC
Delta-BHC
Beta-BHC
Gamma-BHC

SOURCE: Neighborhood boundaries adopted from the Proposed Habitability Criteria document (NYSDOH and DHHS/CDC, 1986)

Figure 6-9

SOIL ASSESSMENT — INDICATOR CHEMICALS SUMMARY OF UNIVARIATE COMPARISONS: EDA SAMPLING AREA TO COMPARISON AREA


5
4
GREENWALD AV
BLACK CR
COLVIN
6
SAMPLING AREA BOUNDARY
3
LOVE CANAL
WHEATFIELD AV
7
2
CENTER
1

LEGEND:

↑ LCIC concentrations in this EDA sampling area are generally greater than those in the comparison area at the 0.05 level of significance (two-sided)

○ No significant difference

↓ LCIC concentrations in this EDA sampling area are generally less than those in the comparison area at the 0.05 level of significance (two-sided)

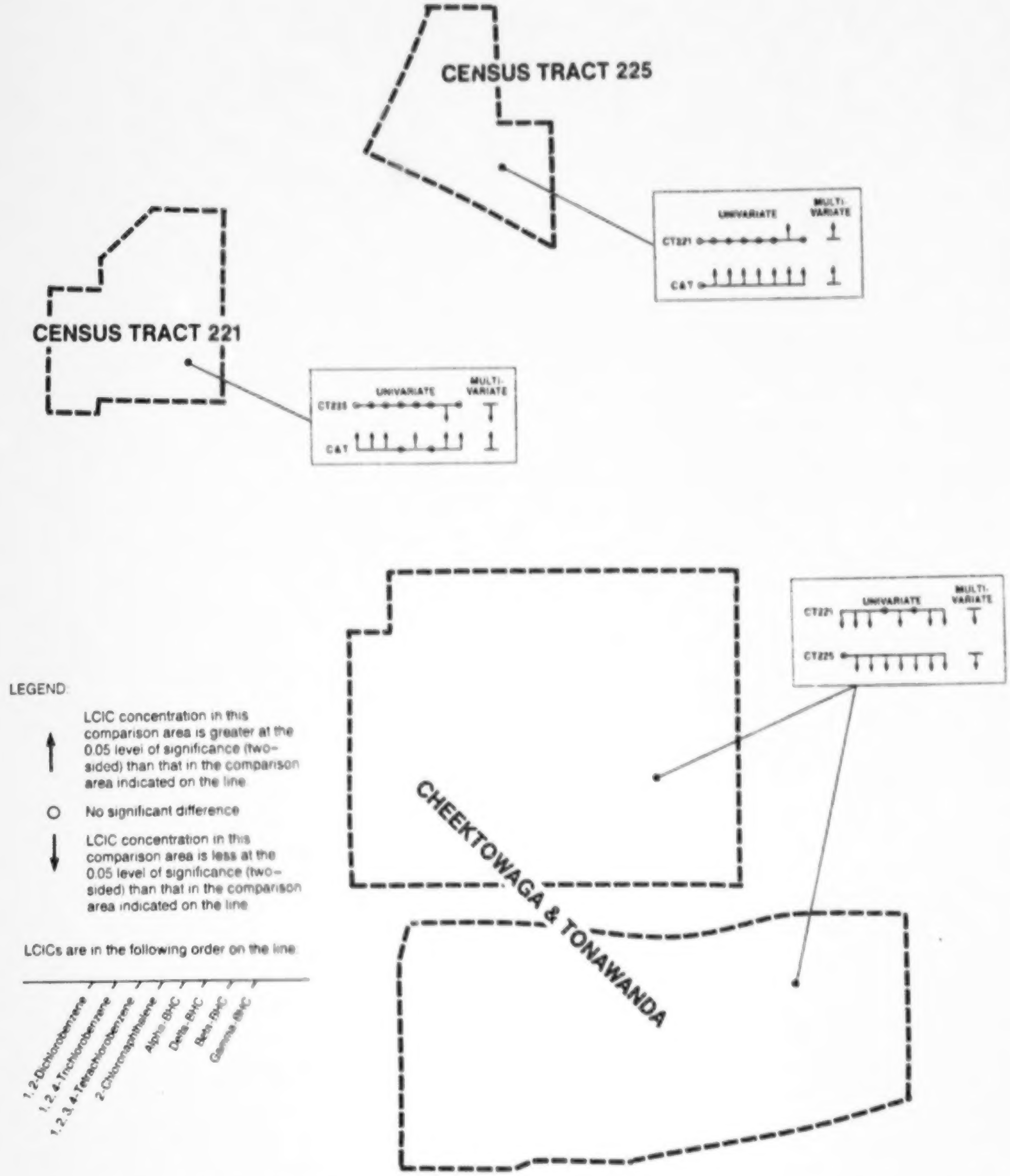
Comparison area symbols are in the following order:

CT221 CT225 CK & TON

NOTE: The direction of the difference between the EDA and Comparison areas is based on the sign of the sum of the elements of the 8 × 1 vector of rank-sums (Appendix B).

SOURCE: Neighborhood boundaries adopted from the Proposed Habitability Criteria document (NYSDOH and DHHS/CDC, 1986)

Figure 6-10
SOIL ASSESSMENT — INDICATOR CHEMICALS
SUMMARY OF MULTIVARIATE COMPARISONS
(LCICs AS A GROUP)
EDA SAMPLING AREA TO COMPARISON AREA


CENSUS TRACT 225
UNIVARIATE
MULTI-VARIATE
CT221
C&T
CENSUS TRACT 221
UNIVARIATE
MULTI-VARIATE
CT225
C&T
UNIVARIATE
MULTI-VARIATE
CT221
CT225
CHEEKTOWAGA & TONAWANDA

LEGEND:

↑ LCIC concentration in this comparison area is greater at the 0.05 level of significance (two-sided) than that in the comparison area indicated on the line

O No significant difference

↓ LCIC concentration in this comparison area is less at the 0.05 level of significance (two-sided) than that in the comparison area indicated on the line

LCICs are in the following order on the line:

1,2-Dichlorobenzene
1,2,4-Trichlorobenzene
1,2,3,4-Tetrachlorobenzene
2-Chloronaphthalene
Alpha-BHC
Delta-BHC
Beta-BHC
Gamma-BHC

NOTE: The direction of the difference between the EDA and Comparison areas for the Multivariate comparison is based on the sign of the sum of the elements of the 8 × 1 vector of rank-sums (Appendix B).

Figure 6-11
SOIL ASSESSMENT —INDICATOR CHEMICALS
SUMMARY OF STATISTICAL COMPARISONS:
COMPARISON AREA TO COMPARISON AREA,
UNIVARIATE AND MULTIVARIATE

A second effect that influences only the univariate test results is that of correlation among the LCICs. Because some of the LCICs are correlated (see Appendix B), there is some redundancy in the information contributed by different LCICs about the sampled areas. For instance, the BHC isomers tended to correlate with other isomers of BHC. Similarly, for example, if a high value of 1,2,4-trichlorobenzene was found in a given sample, a high concentration of 1,2,3,4-tetrachlorobenzene was also likely to occur. This means that if one LCIC is found to be significantly different in two areas, the LCICs highly correlated with it will also tend to be significantly different. This effect also occurs even if there are no differences between sampling areas (null hypothesis is true), resulting in an increase in the apparent rejections that would be due to chance ("false positives"). The effect of correlation among the LCICs is explicitly accounted for in the multivariate test. The multivariate test results give an overall picture of differences between the EDA sampling areas and the comparison areas with respect to all the LCICs.

In Tables 6-8 to 6-10, there were very few changes in the comparison results between those carried out at the 0.01 and 0.05 significance levels, indicating that most of the differences were more than marginally significant.

Additional analyses of a supplementary nature were carried out and are reported in Appendix K. Two kinds of data sensitivity analyses were performed: First, the effect of relaxing the data quality control to include "uncertain" data was considered. Second, the effect of classifying all data below 1 ppb as non-detects was considered. It was concluded that these changes had only minimal effect on the comparison results. In addition, it was determined that the Wilcoxon rank-sum test, applied to laboratory blocked data (described in Section 5.5), met the statistical goal for the statistical comparisons as set forth in Section 3.0.

As directed by the TRC, the purpose of this assessment is to present data and is specifically not to develop conclusions or interpretations of the data. The findings of this study will be reviewed by a panel of scientists. In accordance with the habitability criteria document (NYSDOH and DHHS/CDC, 1986), the results will then be presented to the Commissioner of Health for the State of New York for use in a determination of habitability.

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APPENDIX A
Statistical Concepts

Appendix A
STATISTICAL CONCEPTS

The soil habitability study involved the use of a comparison approach to determine whether an EDA sampling area, taken as a whole, had different (higher or lower) LCIC concentrations than a specified comparison area. Both the design of the sampling protocol and the analysis of the data were conducted in a statistical framework. This appendix reviews some basic statistical concepts that are needed to understand the statistical sampling design (Section 4.2), the statistical methods (Section 5.5), the statistical results (Section 6.4), and the supporting material presented in Appendices B, I, J, and K.

INTRODUCTION

What do we mean by "different" and how do we measure this? Comparing two single numbers is easy--10 is different (and larger) than 6. Comparisons between EDA sampling and comparison areas are harder. Are the 50 or more LCIC sample concentrations (from 50 or more soil samples for example) different than the 50 or so LCIC sample concentrations from the comparison area? While some values may be larger and some smaller, the values are variable both within and between the two areas, regardless of whether or not contamination is present, because of natural spatial variability, imprecise measurement procedures, and for other reasons discussed in Section 4.2.

Statistical hypothesis testing is a formal, mathematical procedure for taking sets of imprecise (variable) data and making comparisons as to whether the data sets are different.

The sets of data can be represented by probability distributions (also referred to as probability density functions). The area under the probability density function in any given interval is the probability that a sample drawn from that probability distribution will have a value (e.g., concentration) in that interval (see Figure A-1).

Figure A-2 illustrates the essential elements of a statistical comparison. Usually some measure of the data, a test statistic, is used for comparison. For the illustrations here, assume that the median concentration can be used to represent the data. If an unlimited amount of data were available, the true median could be calculated exactly. However, in practice sample sizes are finite, the true median cannot be known, and the sample median must be considered to be an estimate of the true median, with some associated uncertainty. Different sets of samples would give different values for the sample median. Figure A-2(b) depicts the probability distribution of the median. In some cases, probability theory will permit an estimate of this probability distribution from the probability distribution of the underlying process, i.e., the concentrations.

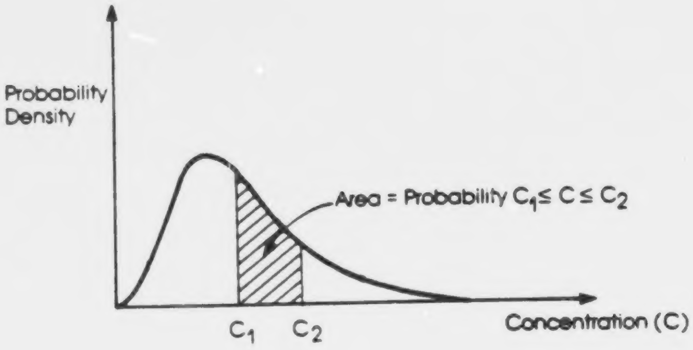


Figure A-1
PROBABILITY DENSITY FUNCTION

To make a comparison, a working hypothesis is needed. The usual hypothesis in statistical testing of the type described here is that (the probability distributions of) concentrations from the EDA sampling and comparison areas are the same. In the hypothetical example, this is equivalent to a statement that the medians are equal or the difference in medians is zero. This primary hypothesis is defined as the null hypothesis. It is the hypothesis that is addressed by statistical comparison tests.

The next step, shown in Figure A-2(c), is to determine the probability distribution (the density function) of the test statistic under the null hypothesis. The null hypothesis assumes that the difference in the medians is zero, but since the sample medians are uncertain their difference is also uncertain. This uncertainty can be represented by a probability density function.

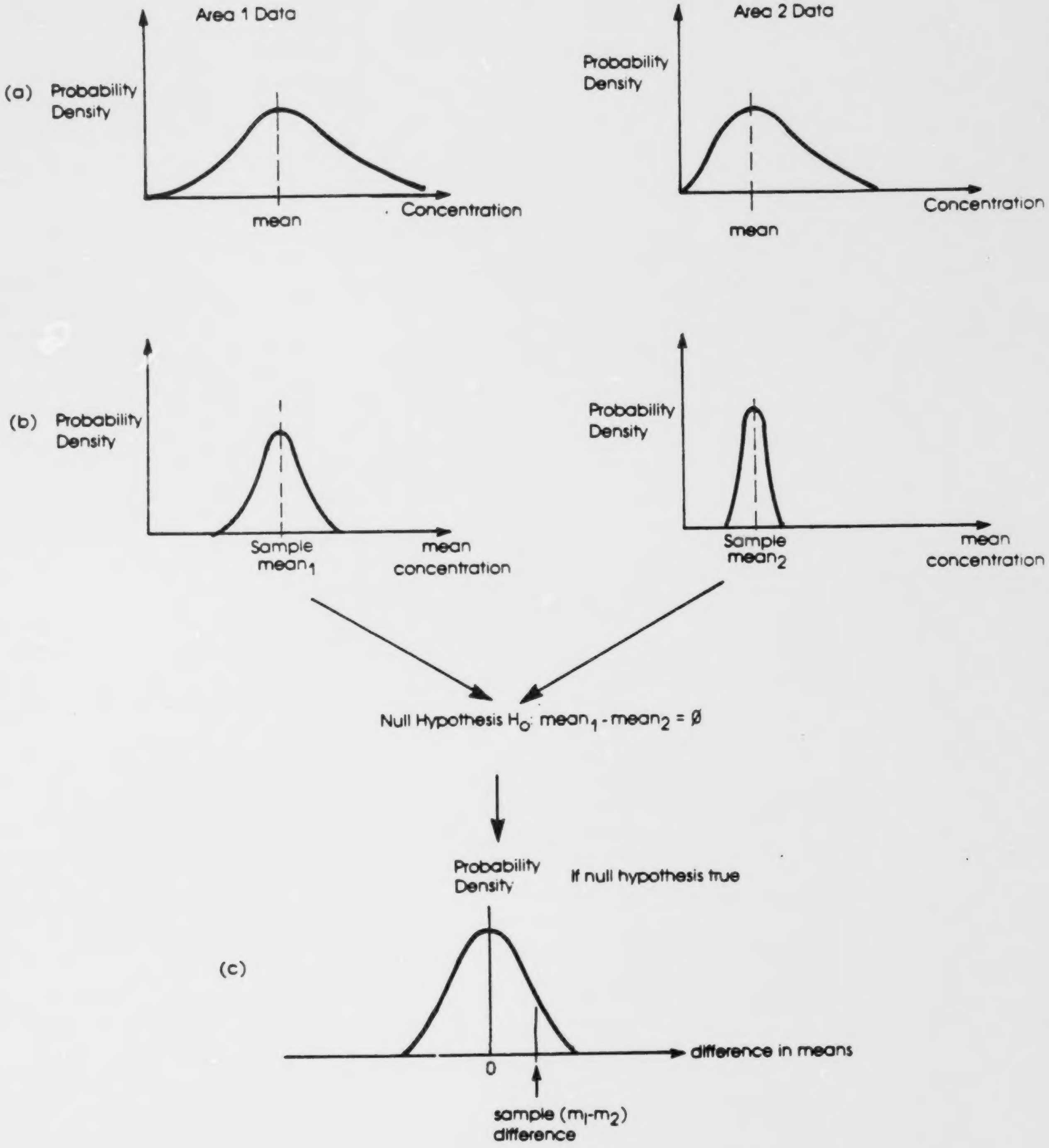
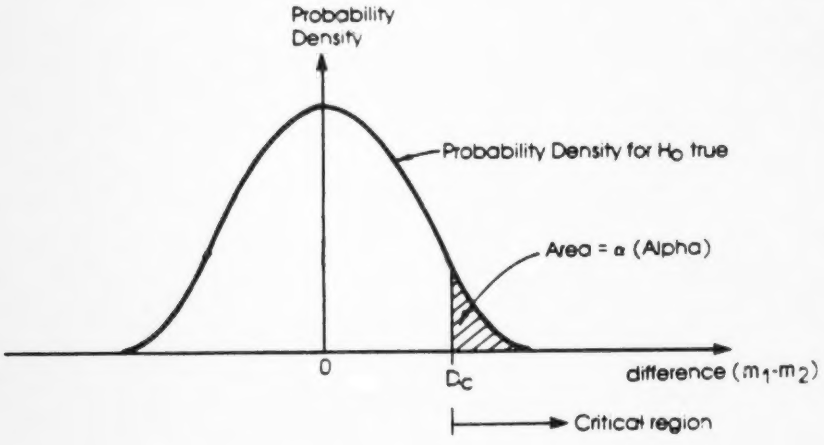

Area 1 Data
Area 2 Data
(a)
Probability Density
mean
Concentration
Probability Density
mean
Concentration
(b)
Probability Density
Sample mean$_1$
mean concentration
Probability Density
Sample mean$_2$
mean concentration
Null Hypothesis H_0: mean$_1$ - mean$_2$ = 0
Probability Density
If null hypothesis true
(c)
0
difference in means
sample (m_1-m_2) difference

Figure A-2
STATISTICAL COMPARISON STEPS

The final step is to test the value of the test statistic (in the example, the difference of the sample medians, delta) as to whether it is consistent statistically with the probability distribution under the null hypothesis. Under the null hypothesis, the expected value of delta, the difference in the sample medians, is zero. Therefore, delta is tested to see if it is significantly different from zero.

The significance level is the probability of rejecting the null hypothesis (H_o) when it is in fact true. This probability, often described by the symbol alpha, represents the probability of making the error of rejecting H_o when it should be accepted; this error is referred to as a Type I error.

If the only concern is positive deltas (i.e., whether the EDA has a higher median than the comparison area), then specifying alpha allows one to calculate a critical value D_c as shown in Figure A-3. Any sample value of delta equal to or greater than D_c results in rejecting the null hypothesis that there is no difference in the two data sets.

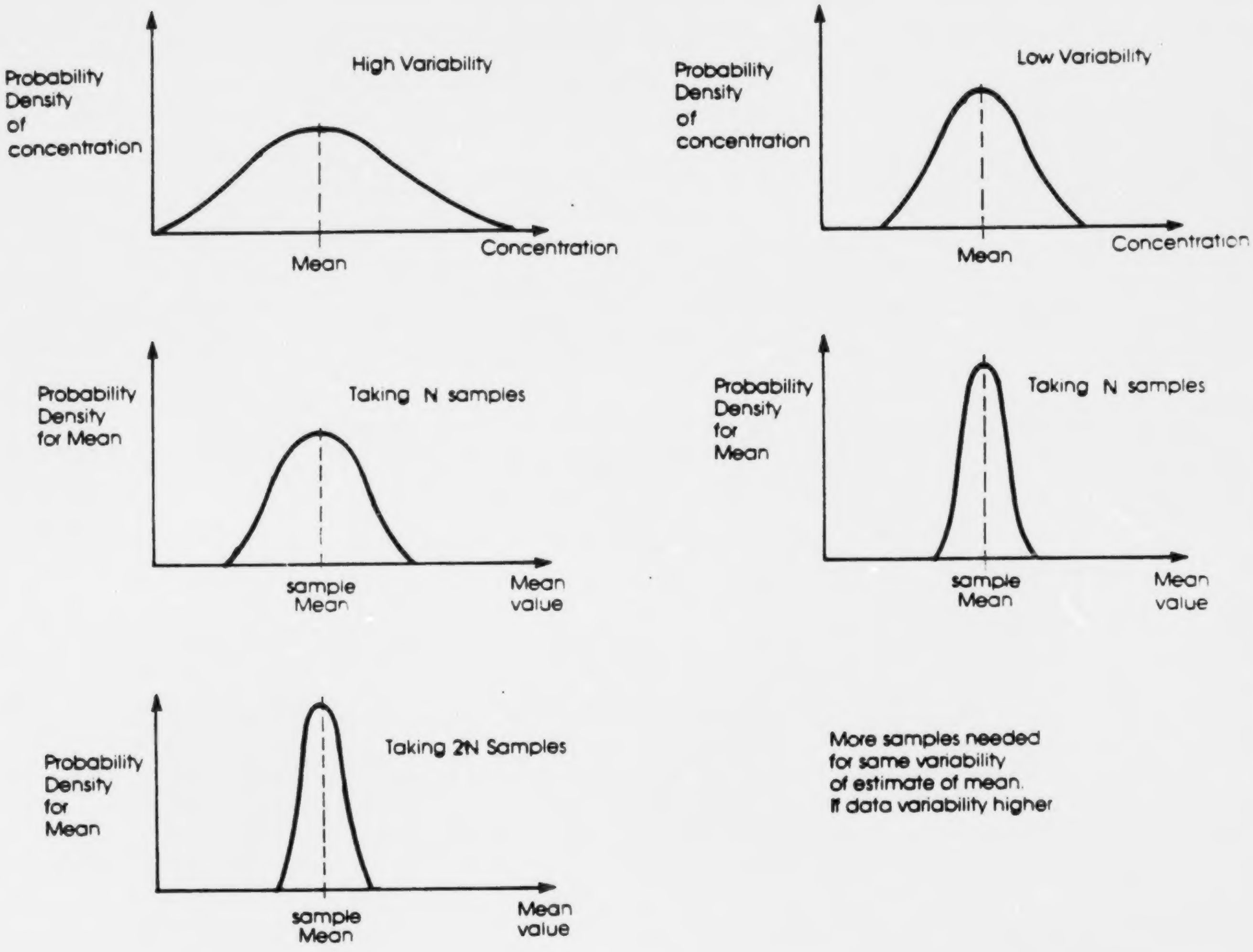


If the samples give $m_1 - m_2 \geq D_c$, reject H_o

Figure A-3
LOCATION OF THE CRITICAL REGION

There are several points to keep in mind:

- The statistical test is carried out on a test statistic (in this example the difference in the sample medians), where the probability density is derived from the probability distribution of the concentrations and the number of samples. Therefore, taking more samples reduces the variability in the test statistics. A larger variability in the underlying process (the concentration data) increases the variability in the test statistics. Figure A-4 illustrates this.


Probability Density of concentration
High Variability
Mean
Concentration
Probability Density of concentration
Low Variability
Mean
Concentration
Probability Density for Mean
Taking N samples
sample Mean
Mean value
Probability Density for Mean
Taking N samples
sample Mean
Mean value
Probability Density for Mean
Taking 2N Samples
sample Mean
Mean value

More samples needed for same variability of estimate of mean. If data variability higher

Figure A-4
INFLUENCE OF SAMPLE SIZE ON VARIABILITY

- In the comparison example above, the null hypothesis H_o is accepted or rejected. No reference is made to what is accepted if H_o is rejected, beyond the statement that the two comparison parameters are statistically different. It is not explicitly determined "how different" one area is. What can be analyzed is the probability of detecting a given difference, the minimum unacceptable difference. The minimum unacceptable difference is the smallest difference that will imply that the EDA is not habitable. This is usually called the alternative hypothesis, H_a. The probability of detection at this given difference is referred to as the power of the statistical test. Figure A-5 illustrates the relationship between the probability determination for H_o and H_a and the power curve.

Computationally, power is the area under the H_a probability density curve to the right of D_c (see Figure A-5), the critical value defined earlier. The area under the H_a probability density curve to the left of D_c (i.e., for values of the sample difference where H_o would not be rejected) is known as beta (one minus power) and is referred to as the Type II error. It is sometimes also referred to as the "false negative" probability. A Type II error occurs when H_o is accepted when in fact it is not true.

SOURCES OF VARIABILITY

A set of concentration data is the end result of collecting and analyzing samples. A data value can be thought of as being comprised of (the sum of) a "true" value and a random "error" component. An important component of the random error is natural spatial variability, for instance, within a comparison area. In addition to this spatial variability, there are a variety of sources of error that are related to the data collection and sample analysis procedures. Some of these sources are:

- Sample collection variability. It is possible that sample collection procedures may introduce variability in the measured concentrated values.

- Sample handling variability. Some of the contaminants of interest are volatile organics. If they are not properly handled and carefully stored, their concentrations may not correctly reflect field concentrations.

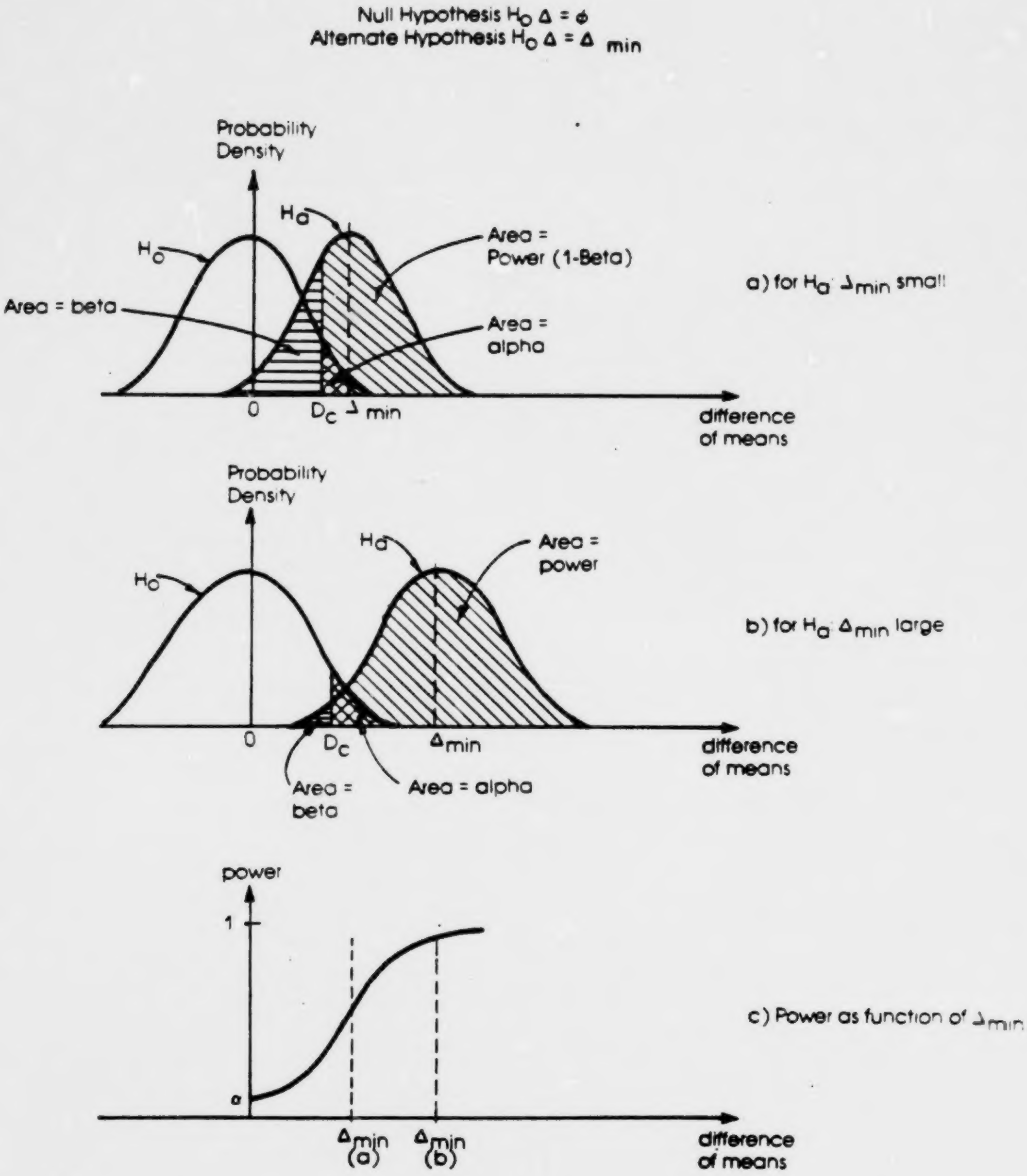

Null Hypothesis H_o $\Delta = \phi$
Alternate Hypothesis H_o $\Delta = \Delta_{min}$
Probability Density
H_o
H_a
Area = Power (1-Beta)
Area = beta
Area = alpha
0
D_c
Δ min
difference of means
a) for H_a: Δ_{min} small
Probability Density
H_o
H_a
Area = power
0
D_c
Δ_{min}
difference of means
Area = beta
Area = alpha
b) for H_a: Δ_{min} large
power
1
α
Δ_{min} (a)
Δ_{min} (b)
difference of means
c) Power as function of Δ_{min}

Figure A-5
INFLUENCE OF Δ_{min} (MINIMUM ACCEPTABLE DIFFERENCE)
ON THE PROBABILITY OF DETECTION (POWER)

- In the comparison example above, the null hypothesis H_o is accepted or rejected. No reference is made to what is accepted if H_o is rejected, beyond the statement that the two comparison parameters are statistically different. It is not explicitly determined "how different" one area is. What can be analyzed is the probability of detecting a given difference, the minimum unacceptable difference. The minimum unacceptable difference is the smallest difference that will imply that the EDA is not habitable. This is usually called the alternative hypothesis, H_a. The probability of detection at this given difference is referred to as the power of the statistical test. Figure A-5 illustrates the relationship between the probability determination for H_o and H_a and the power curve.

Computationally, power is the area under the H_a probability density curve to the right of D_c (see Figure A-5), the critical value defined earlier. The area under the H_a probability density curve to the left of D_c (i.e., for values of the sample difference where H_o would not be rejected) is known as beta (one minus power) and is referred to as the Type II error. It is sometimes also referred to as the "false negative" probability. A Type II error occurs when H_o is accepted when in fact it is not true.

SOURCES OF VARIABILITY

A set of concentration data is the end result of collecting and analyzing samples. A data value can be thought of as being comprised of (the sum of) a "true" value and a random "error" component. An important component of the random error is natural spatial variability, for instance, within a comparison area. In addition to this spatial variability, there are a variety of sources of error that are related to the data collection and sample analysis procedures. Some of these sources are:

- Sample collection variability. It is possible that sample collection procedures may introduce variability in the measured concentrated values.
- Sample handling variability. Some of the contaminants of interest are volatile organics. If they are not properly handled and carefully stored, their concentrations may not correctly reflect field concentrations.

- Laboratory variability. There is inevitable imprecision in all laboratory results. Laboratory variability can be represented by the probability distribution of the results of analyzing (splits of) a single sample many times.

- Inter-laboratory variability. It is possible that a laboratory could analyze many splits and show relatively low variability, but that all the analyses would yield concentration estimates that were different from those performed by another laboratory.

MULTIPLE COMPARISONS

In the statistical comparisons discussed up to now, it has been assumed that the test statistic is based on two data sets: one from an EDA sampling area and one from a comparison area. On the basis of the test statistic and the specified alpha level (Type I error probability), the given EDA sampling area can be classified as having, or not having, higher concentrations of the LCICs than the comparison area. If such a classification is made sampling area by sampling area for each LCIC, then the probability of incorrectly classifying a sampling area increases substantially for the study as a whole with the number of LCICs compared. A similar problem exists for evaluation of the classification of multiple sampling areas, or for classification of a given sampling area with respect to multiple comparison areas.

For a given LCIC and sampling area-comparison area pair, an alpha of 0.05 implies a 5 percent probability of rejecting the null hypothesis that there is no difference between the EDA neighborhood and the comparison area. This Type I error probability refers to a single LCIC comparison. Now if eight LCIC comparisons are made separately for each EDA neighborhood, and the LCICs are statistically independent, the probability of misclassifying the EDA neighborhood for at least one LCIC increases to almost 34 percent. For a given LCIC with comparisons between seven sampling areas and three comparison areas (21 total comparisons), the probability of at least one misclassification is 66 percent.

There are a number of alternatives that can address this problem. Two of these are:

- Adjust the significance level. The significance level (alpha) for the single comparisons could be adjusted to result in an alpha level that is consistent with respect to the total number of comparisons. If the individual comparisons are between statistically independent data, one approach to doing this is to divide the nominal alpha by the number of comparisons to be made. This is referred to as the Bonferroni correction. The approach is extremely conservative and can result in almost no comparison being significant if a large number of comparisons are made.

- Use a multivariate comparison approach. With a multivariate approach, all the LCIC data for an EDA neighborhood are analyzed together so that the number of comparisons is reduced. This also has the advantage that the correlation between variables is accounted for explicitly. The only complication with the multivariate approach is interpretation. It is possible, for instance, for the multivariate test to indicate a statistically significant difference for the eight LCICs as a group, even though there are no significant differences among individual LCICs. In addition, it may be difficult to interpret the direction of change. For example, the multivariate test may indicate a statistically significant difference between sampling areas when the univariate test on the individual LCICs indicates that four are greater in the EDA sampling area than in the comparison area, and four are less.

APPENDIX B
Development of a Statistical Approach for the Sampling Area Comparisons

Appendix B
DEVELOPMENT OF A STATISTICAL APPROACH FOR THE SAMPLING AREA COMPARISONS

This appendix describes in detail the statistical methodology that was used to design the LCIC soil assessment sampling program and to analyze the resulting data. The appendix is divided into five sections. Section 1 discusses the statistical problems that were encountered in the 1982 habitability study and emphasizes the comparison approach basis of the present study. Section 2 describes the process that was followed to determine an appropriate statistical model for the LCIC data and to determine an appropriate statistical method (based on this model) to perform the comparisons. Section 3 briefly describes how the sampling design was created based on the chosen statistical model and method. Section 4 describes the slightly modified statistical model and method that were used to analyze the resulting LCIC data. Finally, Section 5 gives a retrospective power analysis, based on the observed distributions of the LCICs in the comparison areas.

B.1 BACKGROUND

The assessment of EDA habitability with respect to soil chemistry was initially based on data resulting from an environmental study released in 1982 (U.S. EPA, 1982). The primary objective of the 1982 study was to characterize soil chemistry in the Love Canal area; comparison of the EDA soil chemistry with comparison areas was not an original objective of the study. However, the 1982 study results were analyzed using a comparison approach; that is, chemical concentrations estimated from soil samples collected in Love Canal neighborhoods were compared to samples from a control neighborhood. During subsequent review, the conclusions of the study regarding habitability were called into question (OTA, 1983). Specifically, questions arose pertaining to the quality and limits of detection of some of the soil (and other media) samples and the appropriateness of the statistical design.

Because the 1982 study was not originally intended to compare EDA areas with control areas, the design was highly imbalanced: EDA sample sizes were much larger than those from the control area. In addition, the fraction of nondetectable concentrations was extremely high (more than 95 percent for most of the chemicals that were analyzed).

The 1982 study conclusions regarding habitability were set aside following external review, largely because the small sample sizes in the control area precluded any statistical comparison from achieving an adequate power to detect possible differences between the Love Canal and control area, and because laboratory analyses were of unknown quality. The present study was initiated largely to provide a data collection design and results that would avoid the problems encountered in the 1982 study and to enable a valid statistical comparison approach to be implemented. The problems encountered in the 1982 study highlight the importance of using a proper experimental design to aid in reaching a decision regarding the habitability of the EDA.

The current study was based on a statistical comparison approach, as directed by the TRC (NYSDOH and DHHS/CDC, 1986). The EDA neighborhoods were to be compared to one or more "similar" neighborhoods that were known to be distant (>1/2 mile) from any hazardous waste site. Early in the study, the EDA was subdivided into 13 neighborhoods, which were later aggregated into seven EDA sampling areas. One aggregate comparison area was selected that was later augmented with two additional comparison areas. The EDA sampling areas and comparison areas were selected on the basis of socioeconomic, geographic, and other factors (NYSDOH and DHHS/CDC, 1986).

In the design of a statistical assessment procedure to implement the comparison method, several questions were addressed:

1. What are the most appropriate statistical methods?

2. How should samples be allocated to the EDA and comparison areas to assure that the comparison procedure is sufficiently sensitive to differences, if any, between the EDA and comparison areas?

3. How can the experimental design account for unavoidable within-laboratory variability and interlaboratory differences in analytical methods? The decisions made regarding each of these issues, and the analyses that were conducted to support the decisions, are summarized in this appendix. The proposed statistical analysis methods and field sampling design were reviewed by a peer review panel, which met in Niagara Falls on March 24-26, 1987. The peer reviewers supported the concept of the comparison approach and its implementation through the field sampling design and the statistical analysis procedure. The peer reviewers' comments are summarized in Peer Review of the Love Canal Full-Scale Sampling Plan (Life Systems, 1987). The substantive comments of the peer reviewers are addressed in this appendix.

B.2 INITIAL STATISTICAL MODEL AND EVALUATION OF STATISTICAL METHODS

On the advice of the TRC, a decision was made that the soil chemical characteristics of the comparison areas were to be considered fixed. That is, although samples collected in each comparison area were intended to provide a statistically representative sample of conditions in those particular comparison areas, neither the comparison area samples nor the comparison areas themselves could necessarily be considered to be statistically representative of the soil chemistry in the Niagara Falls-Buffalo area taken as a whole. The comparison areas were, however, thought to be typical of conditions in the larger area.

In a statistical sense, the above is equivalent to the statement that the comparison areas were treated as fixed, rather than random, effects in the comparisons. This distinction is important because it essentially means that the comparison between any given EDA sampling area and comparison area should be interpreted individually.

B.2.1 Initial Model and Candidate Statistical Tests

The decision to design a comparison study leads directly to the consideration of two-sample statistical tests. When work was initiated on the statistical design, the extent of interlaboratory differences was unknown, and the basic model for a single LCIC that was considered was:

$$C_{k\ell} = M_k + e_{k\ell} \qquad \text{(B.1)}$$

where:

$C_{k\ell}$ = the concentration of the the ℓ'th observation in sampling area k

M_k = the mean or median concentration in sampling area k (FIXED)

$e_{k\ell}$ = random error in the ℓ'th observation in sampling area k (RANDOM)

k = 1,2 (sampling area index; 1 = EDA, 2 = comparison area)

$\ell = 1,\ldots,n_k$ (sampling area replicate index)

The $e_{k\ell}$ terms were considered to be independent random variables with mean zero that represent four sources of variability: (1) between-laboratory variability, (2) within-laboratory variability, (3) variability between sampling sites within a given sampling area, and (4) variability associated with other factors that were not explicitly modeled (e.g., collection procedures, storage, transportation, etc).

In terms of the model of Eq. B.1, the habitability criteria specify a comparison of the magnitude and direction of the M_k terms. To perform these comparisons, four classes of univariate tests were considered:

1. Two-sample location tests including Student's t-test (Zar, 1984) and the Wilcoxon rank-sum test (Hollander and Wolfe, 1973)
2. Two-sample dispersion tests including Shorack's APF-test (Shorack, 1969)
3. Two-sample proportion tests including Fisher's exact test (Zar, 1984)
4. Two-sample distribution tests including the Kolmogorov-Smirnoff test and the Mood quantile test (Zar, 1984)

In addition, two multivariate tests were considered:

1. The multivariate Wilcoxon rank-sum test (Puri and Sen, 1971; Hettmansperger, 1984)
2. An ad hoc adaptation of the univariate Wilcoxon rank-sum test based on average (over LCICs) ranks

The method of evaluating differences in multiple LCICs is important because of what is known in statistics as the multiple comparison problem, which is discussed in Appendix A. Multivariate tests circumvent this problem by simultaneously testing differences in multiple (LCIC) chemicals.

Each of the above univariate and multivariate tests, with the exception of the multivariate Wilcoxon rank-sum test, is described in Attachment G-2 of Volume II of the pilot study report (CH2M HILL, 1987).

B.2.2 Description of the Monte Carlo Study to Evaluate the Candidate Statistical Tests

Based on the model of Eq. B.1, the relative performances of the candidate statistical tests were assessed using Monte Carlo simulation. Monte Carlo simulation involves the repeated generation of synthetic samples with known characteristics from a (specified) random population. Because the true characteristics of the statistical populations are known (such as the difference in means or medians between a hypothetical EDA and comparison area), the power and Type I error level of the statistical tests, and the effect of any deviations from the test assumptions, can be evaluated.

The performances of the candidate statistical tests were assessed with respect to their power as a function of:

- Sample size
- Coefficient of variation of the error terms
- Distribution of the error terms
- The ratio of within-laboratory variability to the remaining sources of variability
- The fraction of analyses that resulted in non-detects

Six distributions were used in the Monte Carlo study:

- Normal (with negative values truncated)
- Lognormal
- Gamma
- Mixed exponential
- Generalized extreme value
- Lognormal mixture

According to the null hypothesis, the distribution of LCIC concentrations in the EDA sampling area is the same as the distribution in the comparison area. According to the alternative hypothesis, the distribution of LCIC concentrations in the EDA sampling area is "shifted" relative to the distribution in the comparison area. Four different kinds of shifts in distribution were used in the Monte Carlo study:

- Additive shift, written as $f_1(x-\Delta) = f_2(x)$, where $f_1(y)$ and $f_2(y)$ denote the probability density function (pdf) of the EDA and comparison area samples, respectively
- Scale shift, written as $f_1\{ [(x-M)/c] + M \}/c = f_2(x)$, where M denotes the mean of both the EDA and comparison areas
- Multiplicative shift, written as $f_1(x/c)/c = f_2(x)$
- Upper quantile shift, written as $f_1(x) = p\, f_2(x) + (1-p)g(x)$, where p is a mixing fraction between zero and 1 (but generally near 1), and $g(y)$ is an alternative distribution with a larger variance than that of $f_2(y)$

The first alternative hypothesis represents a simple shift of the EDA area LCIC concentrations relative to those of the comparison area by a constant, that is, all moments of the populations are the same except the mean. Under the scale shift, the EDA population of LCIC concentrations has the same mean as the comparison area, but its standard deviation is larger by the multiplicative constant c. The multiplicative shift results in an EDA area population that has the same coefficient of variation as the comparison area, but has a mean and standard deviation that are larger by the multiplicative constant c. Under the fourth alternative hypothesis, the EDA population is a mixture of the comparison area population and a second, more variable population. The upper quantile shift was of particular interest because it represents a situation in which most of the EDA and comparison area samples are drawn from the same distribution, but a few larger values (e.g., areas of localized contamination) occur in the EDA neighborhood.

Because the form of the difference (if any) between the EDA and comparison area populations was unknown, it was important that the test or tests that were selected should perform well over all of the alternative shift hypotheses, even though each test is usually considered optimal for only one of these types of shifts. However, attention was ultimately focused on the multiplicative and upper quantile shifts, which were felt to be the most reasonable. The additive and scale shifts are not compatible with the constraint that the lower bound on LCIC concentration be zero for both the EDA and comparison areas: an additive shift implies that the lower bound (zero) of the EDA population is shifted to the right by the amount Δ (assuming $\Delta > 0$), while a scale shift implies that the lower bound is shifted to the left by a fraction of the mean equal to $c - 1$ (assuming $c > 1$). On the other hand, multiplicative and upper quantile shifts preserve the lower bound of both populations at zero.

B.2.3 Results of the Monte Carlo Study

The performance of each of the tests was evaluated for a range of alternative hypotheses, probability distributions, and statistical parameters. The three univariate tests that performed the best over all the simulations were the Wilcoxon rank-sum test, Shorack's test, and Mood's test. Selected results are given in Table B-1. The ordering of the tests shown in this table is based on the observed power of the tests over a wide range of sample sizes for an order-of-magnitude shift. These orderings, however, are based on the assumption that the nominal alpha-level is maintained under the null hypothesis. Further evaluation of the tests showed that, in some cases, Shorack's test was liberal with respect to Type I error probability; that is, the true alpha-level was greater than the stated value. After attempts were made

Table B-1
SUMMARY OF SIMULATION RESULTS FOR WILCOXON, SHORACK, AND MOOD TESTS

Shift Type[a]	Cv	Percent Nondetect	Order[b]
MLT	2.0	0.85	W,S,M
MLT	2.0	0.95	W,S,M
UPQ	2.0	0.85	S,W,M
UPQ	2.0	0.95	S,W,M
MLT	1.414	0.85	S,W,M
MLT	1.414	0.95	S,W,M

---

[a] MLT = multiplicative shift, UPQ = upper quantile shift with mixing fraction $p = 0.3$. Shift magnitude under the alternative hypothesis was 10 (one order of magnitude) in all cases. Results are for $\alpha = 0.05$, but are generally consistent at other α-levels.

[b] W = Wilcoxon, S = Shorack, M = Mood. Ordering reflects dominant performance over a range of sample sizes from 10 to 100, and generally was consistent for sample sizes larger than 30. For description of tests, see pilot study report, Volume II (CH2M HILL, 1987).

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to modify Shorack's test to maintain the nominal alpha-level, the power of the Shorack test generally dropped below that of the Wilcoxon. Additional analysis of the results also showed that the Mood test was almost always dominated by the Wilcoxon test.

The high power of the Wilcoxon test against the additive shift is generally recognized (Lehmann, 1975). The Wilcoxon test is not generally mentioned in the literature as an effective test against a multiplicative or upper quantile shift (the type of shifts that hold the greatest interest for this study). However, as long as the null hypothesis is that the EDA and comparison area populations are independently identically distributed, it appears that the Wilcoxon test can be expected to perform well relative to alternative candidate tests.

Table B-2 summarizes a comparison of the two multivariate tests. The first test is the nonparametric analogue of Hotelling's two-sample T^2 test (Johnson and Wichern, 1982). It uses an orthogonal rotation of the squares of the univariate Wilcoxon statistics, which can be shown to have (approximately) a chi-squared distribution. This test is described in Hettmansperger (1984) and Puri and Sen (1971). The second test is an ad hoc procedure that applies a univariate Wilcoxon test to a set of ranks that are computed by averaging ranks, computed within each LCIC, over all LCICs. The Monte Carlo simulations were performed in a manner similar to that used for the univariate tests. Results in Table B-2 include cases for which distributional shifts were applied to only one, as well as five, of five chemicals. The results show that although the observed alpha-level of the average rank test is very far below the nominal alpha-level, it performed nearly as well as the usual multivariate Wilcoxon test in terms of power when all five chemicals were shifted. This ad hoc test, however, did not perform as well when only one chemical was shifted.

The general conclusions from the Monte Carlo simulations were:

- The univariate Wilcoxon test performed well regardless of the fraction of nondetectable values. The Wilcoxon test procedure treats nondetectable values as ties, therefore, no change in the formal procedure is required to handle nondetectable values.
- The best proportional allocation of samples to the EDA and comparison area(s) generally has equal sample sizes in each EDA neighborhood and comparison area (balanced design). However, modest deviations from a balanced design do not greatly affect the power of the tests with the best performance.

Table B-2
SUMMARY OF SIMULATION RESULTS FOR THE MULTIVARIATE RANK SUM AND AD HOC AVERAGE RANK TEST[a]

Sample Size	Number of Chemicals Shifted	Nominal α-level	Observed α-level		Power	
			Avg Rank	Mv Rank	Avg Rank	Mv Rank
10	1	.05	.002	.066	.014	.134
10	5	.05	.002	.066	.412	.458
20	1	.10	.006	.102	.028	.302
20	5	.10	.006	.102	.816	.852
30	1	.10	.002	.098	.024	.380
30	5	.10	.002	.098	.940	.970
50	1	.10	.002	.106	.064	.592
50	5	.10	.002	.106	.998	1.000

---

[a] Observations were distributed lognormally with mean 1 and a coefficient of variation 1.414 under the null hypothesis; power results are for an upper quantile shift (contaminated lognormal distribution) with mixing fraction $p = 0.3$, and composite mean 10 (order of magnitude shift) and coefficient of variation 2.0.

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- Using laboratory replicates to reduce the effect of laboratory errors was unwarranted. The cost of laboratory analyses was large relative to the sample collection cost, and resources would be better allocated to increasing the overall sample size as opposed to conducting multiple laboratory analyses on a smaller sample set. This conclusion does not apply to laboratory replication that was conducted as part of the QA/QC program, which had different objectives.

- The usual multivariate Wilcoxon test performed the best for multivariate comparisons of the data.

B.3 CREATION OF THE SAMPLING DESIGN

Based on an assumed difference in median concentration between the EDA and comparison areas of an order of magnitude (as specified in the habitability criteria), initial estimates of sample sizes were required that would allow the design to meet the habitability study objectives of 90 percent power at 95 percent confidence. The appropriate sample sizes were found from the Monte Carlo simulations to be approximately 50 to 100 samples in each EDA neighborhood and comparison area. However, it was recognized that some field data would be required to finalize the sample size requirements and test analytical and field sampling methods. Therefore, a pilot study was undertaken.

A pilot study was conducted in June 1986 to finalize estimates of sample size requirements, test the analytical methods in the laboratories, test field sampling techniques, and develop the QA/QC procedures that would be used in the full sampling study. During the pilot study, 45 samples were collected from random locations throughout the EDA and another 45 were collected in a composite comparison area. The samples were assigned randomly to three laboratories. All samples were split and the second half of the split was assigned at random to one of the two remaining laboratories. The most important results of the pilot study were:

- The EDA samples appeared to be well-fit by a lognormal mixture distribution. Most samples had concentrations near detection limits, but a few relatively high values were found in the EDA.

- Analysis of the sample splits showed that there were substantial differences between the laboratories and, in some cases, the interlaboratory variability was larger than the natural (between-sample) variability in the LCIC concentrations.

Complete results of the pilot study are reported in the Soil Pilot Study Report.

B.4 MODIFIED STATISTICAL ANALYSIS APPROACH

Because of the substantial between-laboratory variability, the statistical design and analysis that was used in the final study included blocking by laboratories. Heuristically, this simply amounts to conducting the Wilcoxon test (univariate or multivariate) for each set of observations analyzed by one laboratory, and then computing an overall statistic by adding the statistics associated with each laboratory. Because the univariate Wilcoxon statistics have (asymptotically) a normal distribution, the sum of the Wilcoxon statistics is also asymptotically normal. Likewise, the individual multivariate statistics for a single laboratory are approximately Chi-squared, so the sum (over laboratories) also is distributed as Chi-squared. The next section describes the model for the LCIC data that is modified to incorporate blocking by laboratories. The section following that describes in detail the statistical methods that were used to analyze the field study data.

B.4.1 The Statistical Model Modified for Blocking

The sampling design that was used for the Love Canal Habitability Study can be modeled as a randomized complete block design (Anderson and McLean) with laboratories classified as blocks and sampling areas classified as treatments. The comparisons between EDA sampling areas and comparison areas can be made separately for each LCIC (a univariate approach), or the information from all LCICs can be combined and used in a multivariate approach. In either case, the general layout of the data can be represented as:

		Sampling Area (Treatment)						
		1 EDA1	2 EDA2	. . .	7 EDA7	8 CT221	9 CT225	10 C&T
	1	n_{11}	n_{12}	. . .	n_{17}	n_{18}	n_{19}	$n_{1,10}$
	2	.						
Lab (Block)	3	.						
	4	.						
	5	.						
	6	.						
	7	n_{71}	n_{72}	. . .	n_{77}	n_{78}	n_{79}	$n_{7,10}$

where n_{jk} represents the number of soil samples from sampling area k (k = 1,...,10) that were analyzed by laboratory j (j = 1,...,7). Note that for ease of notation, laboratories have been arbitrarily labeled sequentially from 1 to 7. This labeling system is totally distinct from the labeling system used in the main body of this report.

A conceptual model for the LCIC measurements that includes the effects of interlaboratory variability is:

$$C_{jk\ell} = M + L_j + A_k + e_{jk\ell} \qquad \text{(B.2)}$$

where:

$C_{jk\ell}$ = the concentration for the ℓ'th observation in sampling area k that was analyzed by laboratory j

M = the overall mean concentration, over areas and laboratories (FIXED)

L_j = block effect because of laboratory j (FIXED)

A_k = treatment effect because of sampling area k (FIXED)

$e_{jk\ell}$ = random error in the ℓ'th observation in sampling area k that was analyzed by laboratory j (RANDOM)

$j = 1,\ldots,7$ (laboratory index)

$k = 1,\ldots,10$ (sampling area index)

$\ell = 1,\ldots,n_{jk}$ (laboratory by area replicate index)

$$\sum_{j=1}^{7} L_j = \sum_{k=1}^{10} A_k = 0$$

Equation B.2 is essentially the same as Eq. B.1, except that the effect of laboratory is treated explicitly in Eq. B.2 as a fixed effect, whereas in Eq. B.1 it is included in the overall error term $e_{k\ell}$.

A more complex model could be postulated that includes a laboratory by sampling area interaction term. However, there is no theoretical justification for such a term, and visual inspection of boxplots of LCIC concentrations by sampling area and laboratory gave no evidence that such an interaction term is necessary. Thus, interaction terms were not used.

The $e_{jk\ell}$ terms are assumed to be independent and identically distributed (iid) random variables with mean zero under the null hypothesis. These error terms reflect the last three of the four sources of variability represented by the error terms in Eq. B.1; that is: (1) within-laboratory variability, (2) between-sampling-site variability, and (3) variability associated with factors not explicitly modeled (for example, data collection procedures, storage, transportation, etc.). The other source of variability accounted for by the error terms in Eq. B.1, between-laboratory variability, has been explicitly modelled in Eq. B.2. A multivariate extension to Eq. B.3 replaces $C_{jk\ell}$ with $\underline{C}'_{jk\ell}$ where $\underline{X}'$ denotes the transpose of a matrix $\underline{X}$, or

$$\underline{C}'_{jk\ell} = (C_{1jk\ell},\ldots,C_{8jk\ell}), \qquad \text{(B.3)}$$

and

$C_{ijk\ell}$ = The concentration of the i'th LCIC for the ℓ'th observation in sampling area k that was analyzed by laboratory j, with i = 1,...,8 (LCIC index)

Similarly, M, L_j, A_k, and $e_{jk\ell}$ are all replaced with their multivariate analogues.

In terms of these models, the habitability criteria specify a comparison of the magnitudes and directions of the effects $A_1,\ldots,A_7$ with the effects A_8, A_9, and A_{10} yielding 7 x 3 = 21 pairwise EDA sampling area--comparison area comparisons. In addition, three pairwise comparison area--comparison area comparisons were performed. Thus, a total of 24 (pairs) x 8 (LCICs) = 192 univariate comparisons were performed, along with 24 multivariate comparisons.

B.4.2 Statistical Methods Modified for Blocking

For univariate comparisons of data that can be described by Eq. B.1, the Wilcoxon rank-sum test is appropriate to compare one EDA sampling area with one comparison area. An obvious heuristic extension to the Wilcoxon test that allows for blocking by laboratory is to compute the Wilcoxon rank sums for within-laboratory-between-sampling-area comparisons, and then to compute a grand statistic by summing over laboratories. The variance of the summed statistic can be computed in a straightforward manner by assuming that no between-laboratory correlation exists.

The extension of the univariate Wilcoxon rank-sum test to account for blocking is presented in various forms by Benard and Van Elteren (1953), Prentice (1979), and Mack and Skillings (1980). A confusing side issue is that these authors refer to their tests as extensions of Friedman's test (Conover, 1980), rather than the Wilcoxon rank-sum test. Table B-3 illustrates why. In the case of only one block and two treatments, however, all three tests reduce to the

Table B-3
RELATIONSHIPS BETWEEN SOME NONPARAMETRIC TESTS

		Number of Treatments	
		2	K
Number of Blocks	1	Wilcoxon Rank-Sum Test n_1, n_2 general	Kruskall-Wallis Test $n_1,\ldots,n_K$ general
	J	Sign Test $n_{j1} = n_{j2} = 1$; $j = 1,\ldots,J$	Friedman's Test $n_{j1} = \ldots = n_{jK} = 1; j = 1,\ldots,J$ Benard & Van Elferen (1953), Prentice (1979), Mack & Skillings (1982) $n_{j1},\ldots,n_{jk}$ general

Wilcoxon rank-sum test. Prentice's (1979) test will now be described in the context of J blocks and two treatments.

In the following, it will be assumed that only two sampling areas are being compared. Thus, n_{j1} will denote the sample size (within laboratory j) in the EDA sampling area that is being considered, while n_{j2} will denote the sample size (within laboratory j) in the comparison area that is being considered. A dot (.) substituted for a subscript denotes the summation over that subscript. For example:

$n_{j.} = \sum_{k=1}^{2} n_{jk}$	The sample size within block (laboratory) j over both treatments sampling areas)
$n_{..} = \sum_{j=1}^{7} \sum_{k=1}^{2} n_{jk}$	The total sample size over treatments and laboratories

The blocked Wilcoxon test is presented in terms of a scaled rank score $r_{jk\ell}/(n_{j.}+1)$, rather than the rank sum, where

$r_{jk\ell}$ = The rank of $C_{jk\ell}$, where ranks are assigned from 1 to $n_{j.}$ within block (laboratory) j, and $n_{j.}$ denotes the number of observations within block (laboratory) j.

It can be shown that under the null hypothesis of no differences between areas, the expected value of $r_{jk\ell}/(n_{j.}+1)$ is 1/2. The centered scaled rank is then defined as

$$R_{jk\ell} = [r_{jk\ell}/(n_{j.}+1)] - (1/2) \qquad \text{(B.4)}$$

To test the null hypothesis of no difference in LCIC concentrations between sampling areas for a single LCIC, the following steps are performed:

1. Compute $W_j = \sum_{\ell=1}^{n_{j1}} R_{j1\ell}$ for j = 1,...,7.

   $R_{j1\ell}$ are the ranks for the data from the EDA sampling area for the sample analyzed by laboratory j. W_j is the sum of the centered scaled ranks within laboratory j for the EDA sampling area.

2. Compute $V_j = n_{j1}\, n_{j2}\, /[12(n_{j.}+1)]$ for j = 1,...,7.

   V_j is the variance of W_j under the null hypothesis of no differences in LCIC concentrations between the EDA sampling area and the comparison area.

3. Compute $Z = W_./\sqrt{V_.}$, where $W_. = \sum_{j=1}^{7} W_j$ and $V_. = \sum_{j=1}^{7} V_j$.

   Under the null hypothesis of no difference in LCIC concentrations between the EDA sampling area and the comparison area, Z is approximately distributed as a standard normal variable.

4. Compute the two-sided p-value as $p = 2[1 - \Phi(|Z|)]$, where $\Phi(y)$ denotes the cumulative distribution function of the standard normal distribution and $|Z|$ denotes the absolute value of Z. The essence of the blocked Wilcoxon test is thus to compute the usual Wilcoxon statistic for each block (laboratory) and then to sum these statistics across laboratories by weighting by (block size + 1) to account for the difference in sample sizes between blocks. Because observations between laboratories are independent, the variance of the sum of these statistics is the sum of the variances of the statistics for each laboratory.

Some variations of Prentice's (1979) extension have been explored. Benard and Van Elteren (1953) base their test on $r_{jk\ell}$, while Mack and Skillings (1980) use $r_{jk\ell}/n_{j.}$. Both Prentice (1979) and Mack and Skillings show that their approach is more efficient than that of Benard and Van Elteren (1953). Prentice's approach, however, is the most computationally convenient. Some exploratory comparisons of the three variations were conducted for Love Canal-like data and the differences in performance of the three variations of the test were found to be negligible. In addition, Prentice's approach for both the univariate and multivariate case is available on the statistical package SAS under the procedure MRANK (Sarle, 1986).

The blocked Wilcoxon test is easily adapted to the multivariate case. In essence, a multivariate generalization of the Wilcoxon statistic (Puri and Sen, 1971, page 186; 1985, page 185) is computed for each laboratory, along with an estimate of the variance-covariance matrix of this statistic. The multivariate Wilcoxon statistics are then summed over labs, and a chi-squared statistic based on the summed (over labs) variance-covariance matrices is formed.

In order to describe the multivariate test that was used to compare sampling areas, it will be convenient to refer to Eq. B.3 and to introduce the following notation:

$$\underline{r}'_{jk\ell} = (r_{1jk\ell},\ldots,r_{8jk\ell})$$

$r_{ijk\ell}$ = The rank of $C_{ijk\ell}$, where ranks are assigned from 1 to nj. within block (laboratory) j; ranking is performed separately for each of the eight LCICs

$\underline{R}'_{jk\ell} = (R_{1jk\ell}, \ldots, R_{8jk\ell})$

$R_{ijk\ell} = [r_{ijk\ell}/(n_{j.}+1)] - (1/2)$

$\underline{R}_j \quad = [\underline{R}_{j11}, \ldots, \underline{R}_{j1n_{j1}}, \underline{R}_{j21}, \ldots, \underline{R}_{j2n_{j2}}]$

$\underline{R}_j$ is simply the 8 x $n_{j.}$ matrix of centered scaled ranks for block (laboratory) j.

To test the null hypothesis of no difference in LCIC concentrations between sampling areas for all of the LCICs, the following steps are performed:

1. Compute $\underline{W}_j = \sum_{\ell=1}^{n_{j1}} \underline{R}_{j1\ell}$ for j = 1,...,7.

   $\underline{W}_j$ is the sum of the centered scaled rank vectors within laboratory j for the EDA sampling area.

2. Compute $\underline{V}_j = (n_{j1}n_{j2}/n_{j.})[(\underline{R}'_j\underline{R}_j)/(n_{j.}-1)]$ for j = 1,...,7

   $\underline{V}_j$ is the estimated variance-covariance matrix of $\underline{W}_j$ under the null hypothesis of no differences in LCIC concentrations between the EDA sampling area and the comparison area.

3. Compute $X^2 = \underline{W}_.'(\underline{V}_.^{-1})\underline{W}_.$, where $\underline{W}_. = \sum_{j=1}^{7} \underline{W}_j$, and $\underline{V}_. = \sum_{j=1}^{7} \underline{V}_j$.

   Under the null hypothesis of no difference in LCIC concentrations between sampling areas for any of the LCICs, the statistic X^2 is approximately distributed as chi-squared with 8 degrees of freedom.

4. Compute the two-sided p-value as $p = 1 - F_8(X^2)$, where $F_8(y)$ denotes the cumulative distribution function of the chi-squared distribution with 8 degrees of freedom.

It should be noted that the samples sizes that were used in the sampling design in order to achieve the specified power requirements were based on the model of Eq. B.1, in which between-laboratory variability is incorporated into the error term. Because between-laboratory variability is substantial, however, and because the above tests explicitly account for blocking, the actual power of these tests should have exceeded the 90 percent power requirement set by the habitability criteria. This was indeed the case as reported in the next section.

B.5 RETROSPECTIVE POWER OF THE SAMPLING DESIGN

One of the study goals was to provide 90 percent power of detecting an order-of-magnitude difference between each EDA sampling area and comparison area at 95 percent confidence. Power is primarily a design issue to be addressed prior to data collection. However, it is possible to perform a retrospective analysis to determine what the power would have been given an underlying probability distribution with parameters estimated from the observed field data collected in the comparison areas. (Distribution parameters estimated from the EDAs are not appropriate because these areas are presumed to (possibly) be characterized by a distribution other than that corresponding to the null hypothesis.) Monte Carlo simulations were conducted using the blocked univariate and multivariate Wilcoxon procedures described in the previous section, using coefficients of variation, nondetect fractions, and (in the case of the multivariate tests) inter-variable correlations estimated from the soil chemistry data. The following assumptions were made:

1. The data are lognormally distributed.

2. The alternative hypothesis is a multiplicative (constant coefficient of variation) shift.

3. For each chemical, the log-space standard deviation of the "natural" process (not including interlaboratory variability) was taken to be the average sample value over all laboratories and neighborhoods (note that the log space standard deviation is a function of the real space coefficient of variation only, which is unaffected by a multiplicative shift, if one exists).

4. The percentage of nondetects for each chemical was taken as the average over the three control areas for all laboratories.

5. The interlaboratory variance was taken to be 0.5 of the total variance (natural variability plus interlaboratory variability).

The results are summarized in Tables B-4 through B-7. The results show that for all but a few of the LCICs, the statistical test had the desired power (90 percent for alpha = 0.05) for a delta of 1.0 (a 100 percent shift), and in all cases the power of the test was essentially 1.0 for an order-of-magnitude shift. The results give confidence that the design had at least the required sensitivity to concentration differences between the EDA and comparison areas in all cases.

Table B-4
SUMMARY STATISTICS USED IN THE MONTE CARLO SIMULATION FOR THE RETROSPECTIVE POWER ANALYSIS[a]

LCIC	CV[b]	ND[c]	Vt[d]	XT[e]
chlorobenzene (1)	.45	0.0	.583	0.0
dichlorobenzene (2)	.89	0.0	.974	0.0
trichlorobenzene (3)	1.02	7.5	1.06	.124
chloronaphthalene (4)	.34	35.5	.456	.761
alpha-BHC (5)	3.25	51.2	1.76	.228
delta-BHC (6)	.95	93.0	1.02	2.68
beta-BHC (7)	1.55	75.1	1.33	1.02
gamma-BHC (8)	1.14	84.9	1.13	1.69

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[a] Inter-laboratory variance assumed to be 50 percent of total; essentially identical results were achieved when interlaboratory variance was assumed to be 25 percent of total.

[b] Coefficient of variation derived from average (overlaboratories and neighborhoods) log standard deviation.

[c] Estimated non-detect fraction (average over comparison areas) in percent.

[d] Log space standard deviation (square root of sum of "natural" variance and inter-laboratory variance).

[e] Inferred non-detect level, as fraction of mean.

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Table B-5
POWER (AT α = 0.05) FOR UNIVARIATE TESTS BASED ON PARAMETERS ESTIMATED FROM "GOOD" DATA GIVEN IN TABLE B-4, FOR INTER-LABORATORY VARIANCE FRACTION = 50%

Delta[a]	LCIC 1	2	3	4	5	6	7	8
0.00	.050	.050	.050	.044	.048	.056	.058	.042
0.05	.122	.088	.086	.140	.062	.076	.074	.070
0.10	.244	.144	.130	.322	.096	.088	.104	.084
0.20	.616	.286	.254	.756	.136	.124	.152	.156
0.50	.988	.808	.756	1.000	.338	.354	.412	.452
1.00	1.000	.990	.982	1.000	.676	.740	.808	.832
2.00	1.000	1.000	1.000	1.000	.958	.984	.994	.998
5.00	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

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[a] LCIC concentrations in EDA sampling areas are drawn from a statistical population related to that of the comparison area by the factor 1+delta; delta = 10.0 corresponds to an order of magnitude shift.

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Table B-6
POWER FOR MULTIVARIATE TEST FOR PARAMETERS GIVEN IN TABLE B-4 AND INTERVARIABLE CORRELATION GIVEN IN TABLE B-7, FOR INTERLABORATORY VARIANCE FRACTION 0.5

	Alpha				
Delta[a]	.0100	.0250	.0500	.1000	.2000
.00	.000	.006	.022	.066	.176
.05	.000	.000	.022	.072	.192
.10	.000	.004	.034	.102	.216
.20	.014	.048	.096	.174	.340
.50	.256	.402	.528	.656	.808
1.00	.920	.968	.990	.994	.998
2.00	1.000	1.000	1.000	1.000	1.000
5.00	1.000	1.000	1.000	1.000	1.000
10.00	1.000	1.000	1.000	1.000	1.000

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[a] LCIC concentrations in EDA sampling areas are drawn from a statistical population related to that of the comparison area by the factor 1+delta; delta = 10.0 corresponds to an order of magnitude shift.

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Table B-7
INTERVARIABLE CORRELATIONS USED IN SIMULATIONS
(BASED ON AVERAGE RANK CORRELATION FOR "GOOD" DATA)

	LCIC							
LCIC	1	2	3	4	5	6	7	8
1	1.000	.591	.495	.333	.444	.410	.412	.344
2	.591	1.000	.957	.119	.750	.590	.591	.573
3	.495	.957	1.000	.095	.753	.610	.626	.601
4	.333	.119	.095	1.000	.160	.240	.080	.160
5	.444	.750	.753	.160	1.000	.670	.760	.687
6	.410	.590	.610	.240	.670	1.000	.670	.670
7	.412	.591	.626	.080	.760	.670	1.000	.600
8	.344	.573	.601	.160	.687	.670	.600	1.000

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APPENDIX C
Analytical Method Development

Appendix C
ANALYTICAL METHOD DEVELOPMENT

INTRODUCTION

This appendix describes the development of the method used for analysis of the field samples collected for the Love Canal LCIC study. Further details regarding the analytical procedure can be found in the sample laboratory analysis QAPP (CH2M HILL, 1987). Several soil LCIC analytical techniques were considered before the pilot study was conducted, including gas chromatography with electron capture detection (GC/ECD), gas chromatography mass spectrometry (GC/MS), and isotope dilution GC/MS. Ultimately, however, selected ion monitoring GC/MS (GC/MS/SIM) was chosen because it can provide suitable sensitivity and selectivity for LCIC analysis (see CH2M HILL, 1987 Appendix F). GC/MS/SIM, which is used routinely for several types of environmental analyses, monitors only certain characteristic ions for each target compound. With only a few masses monitored, the sensitivity for each mass channel increases. Enough masses of each target compound must be monitored to confirm the detection of that compound.

A method using GC/MS/SIM was developed and validated for the analysis of soil samples for LCICs and was used successfully for the pilot study. While LCIC concentrations were detected and identified to 1 ppb using this method, LCIC concentrations in the pilot study soil samples from the Emergency Declaration Area (EDA) were mostly less than 1 part per billion (ppb) and a large percentage were non-detects. For example, only 1 percent of the EDA samples had 2-chloronaphthalene concentrations greater than 1 ppb. Chemical interferences, rather than simply low LCIC concentrations, also caused a significant number of non-detects. This was especially true for the BHC isomers, which exhibited hydrocarbon interferences.

MODIFICATIONS TO THE ANALYTICAL METHOD

On the basis of experience gained during the pilot study and the NYSDOH study, a number of modifications were made to the method prior to the habitability study to achieve detection limits of around 0.2 to 0.3 ppb for most of the LCICs. Some of these changes were oriented toward achieving lower detection limits and reducing the degree of chemical interferences, particularly for the BHC isomers. Other modifications were made to improve the productivity and effectiveness of the labs contracted for the study.

In an effort to remove the hydrocarbon interferences, the sample cleanup procedure was scrutinized, and major modifications were made. First, the alumina cleanup column was replaced with a silica gel column, because silica gel was found to be much more efficient than alumina in removing these interferences. Second, the two sulfuric acid cleanup steps were moved to before the silica gel column separation step instead of after. This resulted in a cleaner extract being applied to the silica column, thus improving the performance of the column separation.

In addition, a bicarbonate wash step was added to follow the sulfuric acid cleanup steps; the bicarbonate neutralizes any acid that may be transferred along with the extract. The sulfuric acid cleanup steps were found to cause fairly rapid hydrogen/deuterium exchange for the deuterated internal standards, if any sulfuric acid remained in the extract. This resulted in a severe high bias because of a reduction in the concentration of the internal standards in the extracts. The bicarbonate wash eliminated this problem.

Another modification to reduce the hydrocarbon interferences involved changing the ions monitored for the four BHC isomers: from m/z 181, 183, and 109 to m/z 217, 219, and 183. The higher mass ions were found to be less prone to hydrocarbon interferences. In addition, the ion monitored for the low-level surrogate, 1,2,3,4-tetrabromobenzene, was changed from m/z 392 to m/z 234 so that it would be more subject to the types of interferences experienced by the BHCs.

The changes to reduce the hydrocarbon interferences allowed two additional BHC isomers to be added as LCICs: alpha- and delta-BHC.

Other changes to the pilot study method were made to improve the method detection limits. The volume of the final extract was reduced to 100 µl from 200 µl. Doubling the concentration of the LCICs in the extract effectively lowers the detection limit by a factor of two if the limiting factor is the instrument's sensitivity. By using a more efficient sample cleanup, the LCIC detection limit was lowered.

Another major improvement was to provide the laboratories with solvents and reagents that were subjected to a rigorous set of QC analyses prior to use to select lots in which any LCICs present were at the lowest possible level. Since all laboratories were using the same lots of solvents and reagents, a major source of blank contamination was eliminated and any blank contamination was expected to be laboratory-specific; the use of common lots also helped in determining and eliminating remaining sources of contamination. Using these materials, it was possible to cut in half the allowable blank contamination level from the 1.0 ppb used in the pilot study to 0.50 ppb (0.60 ppb for 1,2-dichlorobenzene).

In addition to using the same lots of solvents and reagents, the laboratories were also provided with identical specialty glassware, consisting of macro- and micro-Snyder columns and silica gel chromatography columns. The identical glassware provided increased comparability between laboratories.

A review of the pilot study data revealed interferences for certain LCICs that made it difficult and, in some cases, impossible to identify LCICs, thus resulting in false negatives. By examining the method/holding blank results, it was determined that the solvents and the reagents were causing some of these interferences. To avoid this during the habitability study, a detailed set of method/holding blank interpretation rules was written into the sample analysis Quality Assurance Project Plan (QAPP) (CH2M HILL, 1987). The rules prohibit interference peaks that are close to the predicted relative retention time (RRT) of an LCIC and are larger than the peaks corresponding to the blank contamination level.

A detailed set of rules for identifying LCICs, similar to the rules regarding blank interpretation, was added to the sample analysis QAPP (CH2M HILL, 1987). These rules, derived from the experience of the pilot study, were intended to allow low-level LCIC data to be interpreted uniformly by all project laboratories.

The levels of all calibration standards and quality control (QC) compounds were adjusted downward from the levels used in the pilot study. To adjust to the lower method detection limits that could be achieved using the modified analytical protocol, the initial calibration range was reduced from 1 through 200 ppb to 0.25 through 10 ppb, and the concentration of the continuing calibration standard was reduced from 2 ppb to 0.5 ppb. In addition, internal standard concentrations were reduced from 20 ppb to 10 ppb; surrogate standard concentrations were lowered from 25 ppb and 1 ppb to 10 ppb and 1 ppb; and matrix spike/matrix spike duplicate levels were reduced from 50 ppb to 5 ppb.

Taken together, the changes described above lowered the method detection limits by approximately a factor of five from about 1 ppb to 0.2 ppb to 0.3 ppb for most of the LCICs. This was as far as the detection limits could feasibly be lowered using the GC/MS/SIM approach for the LCICs.

Other changes in the analytical protocol were made to increase laboratory throughput and provide for greater comparability among the project laboratories. The performance check standard and the continuing calibration standard were combined into the same solution so that fewer QC injections were needed for each analysis shift. The width of the RRT window for each LCIC was reduced from ±0.007 to ±0.005 RRT units, thus reducing the number of peaks that needed to be scrutinized in each chromatogram. Since the instruments were operating in a mode that enabled sub-ppb levels of LCICs to be detected, field samples that were suspected of having high concentrations of LCICs were screened by diluting the extracts prior to analysis. As a control, other field samples not suspected of having high LCIC concentrations were also preselected for screening. This was done to limit the maximum concentrations to which the GC/MS/SIM would be subjected, thus reducing the potential for instrument malfunction or down time.

SUMMARY OF THE MODIFIED ANALYTICAL METHOD

The analytical method that was ultimately developed consisted of solvent extraction, extensive cleanup, and analysis by GC/MS/SIM. After a sample was received and logged into the laboratory, a 20-gram aliquot was weighed out and spiked with a solution containing the three surrogate standards. The soil was then dried to a sandy texture by mixing it with sodium sulfate. The sample was extracted three times for 3 minutes using a mixture of methylene chloride and acetone. A sonicator probe was used to increase the efficiency with which the LCICs were extracted from the soil matrix. The combined extracts were centrifuged, if necessary, to remove soil particles. The extract was dried further by passing it through a sodium sulfate column. The dried extract was reduced in volume by evaporating the solvent using a Kuderna-Danish column with a three-ball macro-Snyder column, followed by further concentration using a two-ball micro-Snyder column. A second two-ball micro-Snyder column was used to exchange the extract sample into a hexane solvent.

In the first of the two cleanup steps, concentrated sulfuric acid was added to the extract, causing a reaction in which many of the polar compounds that could interfere with the LCIC analysis were removed. The extract was then washed with a bicarbonate solution to neutralize any residual acid. In the second cleanup step, the extract was passed through a silica gel column. The composition of the solvent used to extract the silica gel column was carefully selected during method development to yield high recovery of the LCICs while separating them from hydrocarbon interferences. Following silica gel column chromatography, the extract was reduced in volume using macro- and then micro-Snyder columns. This solution was stored in a refrigerator at 4°C until the time of analysis.

Just before analysis, a solution containing the five deuterated internal standards was added to the extract. Using a gentle stream of purified nitrogen gas, the extract window was concentrated to a final volume of 100 µl. A 1- to 2-µl aliquot of the final extract was injected into the GC using a splitless injector. The LCICs were separated using a fused silica column coated with polyphenylmethyl silicone. Following the temperature-programmed GC separation, the LCICs were detected using an electron impact MS operated in the SIM mode. Three characteristic ions were monitored for each LCIC. The instrument response for these ions was required to satisfy the following three criteria to confirm the identity of the LCIC: (1) all three ions must exhibit a peak within 0.005 RRT unit of the daily performance check; (2) all three ions must exhibit peak maxima within two mass spectral scans of each other; and (3) the primary and secondary ions must have a response ratio within 20 percent of the theoretical ratio. For confirmed peaks, quantification was performed using the internal standard that eluted closest in the chromatogram to the LCIC. Further details on the analytical procedure can be found in the sample analysis QAPP (CH2M HILL, 1987).

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APPENDIX D
Holding Time Study

Appendix D
HOLDING TIME STUDY

INTRODUCTION

Prior to the start of field sampling for the soil assessment study, a study was initiated to assess the effects of sample extraction holding time on LCIC concentration. For administrative purposes, the EPA Contract Laboratory Program typically specifies an extraction holding time of not more than 10 days. During the design of the soil assessment study, it was decided that the maximum allowable extraction holding time should be increased to 30 days to allow the field sampling to proceed on schedule. This decision allowed the field sampling to finish prior to adverse winter conditions, yet gave the laboratories adequate time to extract and analyze all of the field samples.

The main purpose of the holding time study was to determine whether LCIC concentrations decrease over time in a soil sample that is held in refrigerated storage in the laboratory before the sample is extracted. The effects of time from extraction to analysis were not specifically investigated. The holding time study showed that there was no significant decrease in LCIC concentration over the studied extraction time.

The field sampling and laboratory methods that were used in the holding time study, and details of the results, are described in this appendix.

METHODS

The holding time study involved collecting 20 soil samples from EDA Neighborhood 1 and 20 soil samples from Neighborhood 3. Neighborhood 1 was chosen because of indications during the pilot study that concentrations of LCICs were elevated compared to other EDA neighborhoods. Neighborhood 3 was taken to be more typical of the remaining EDA neighborhoods.

The samples from each neighborhood were sent to the soil preparation laboratory where they were extruded from the stainless steel liners. All 20 samples from a single neighborhood were mixed for 5 minutes, resulting in two homogeneous batches: one from EDA Neighborhood 1 and one from EDA Neighborhood 3. Each batch of homogenized soil was then split into 20 sample jars. Ten of the jars from each neighborhood, along with one shipping blank jar containing blank soil, were then sent to each of two laboratories (1 and 2) for analysis.

All of the holding time samples were shipped from the soil preparation laboratories to the two analytical laboratories on the same day. Upon receipt of the holding time samples, the analytical laboratories placed the jars in refrigerated storage. The extraction holding time for a particular sample was defined to be the number of days between the day the analytical laboratory received the sample and the day the sample was extracted.

On the day both laboratories received the holding time samples, each laboratory selected two jars at random from each neighborhood batch and analyzed the soil. The analysis for each jar was performed in duplicate, i.e., two separate subsamples were taken from a single jar, extracted, and analyzed. These 16 analyses (2 laboratories x 2 neighborhoods x 2 jars/neighborhood x 2 subsamples/jar) established the LCIC concentrations on day zero.

After the initial day zero analyses, each laboratory was instructed to extract and analyze one sample (jar) per neighborhood (in duplicate) every fifth day. During the next three analysis dates, samples from both neighborhoods were to be analyzed. From then on, starting with the fifth analysis date, samples for a specific neighborhood were analyzed every 10 days. Table D-1 shows the planned holding times for this study. The longest planned extraction holding time for the holding time study exceeded the expected holding times associated with the full field sampling study. Both laboratories analyzed the holding time experiment samples using the same analytical procedures that were used for the field sample analyses.

Table D-1
PLANNED HOLDING TIMES FOR THE HOLDING TIME STUDY

Receipt Date	Extraction Date	Neighborhood Soils Analyzed	Holding Time (days)
10/14/87	10/14/87	1,3	0
10/14/87	10/19/87	1,3	5
10/14/87	10/24/87	1,3	10
10/14/87	10/29/87	1,3	15
10/14/87	11/03/87	3	20
10/14/87	11/08/87	1	25
10/14/87	11/13/87	3	30
10/14/87	11/18/87	1	35
10/14/87	11/23/87	3	40
10/14/87	11/28/87	1	45
10/14/87	12/03/87	3	50
10/14/87	12/08/87	1	55
10/14/87	12/13/87	3	60
10/14/87	12/18/87	1	65

RESULTS OF THE HOLDING TIME STUDY

Table D-2 shows the actual holding times and extraction dates that were used in the holding time study along with the observed concentrations for each LCIC. Note that the samples were received by the analytical laboratories 1 day early, on October 13, 1988, rather than October 14, 1988.

To investigate the effect, if any, of holding time on LCIC concentration, a regression of LCIC concentration versus holding time was performed for each LCIC, each neighborhood, and each laboratory. Only observations that were flagged as "Good" by EMSL-LV/LEMSCO were used for the regressions. The number of observations per regression varied from a maximum possible of 20 to a minimum of 11. The average number of observations per regression was 16.

In cases where concentrations were reported as non-detect (because not all of the qualitative identification criteria were met), the concentration based on the primary ion area was used. This was considered to be the best estimator for non-detectable concentrations because the primary ion area is the basis for quantification when the analytes do in fact pass all of the qualitative identification criteria. In addition, for a specific neighborhood, the holding time samples were from only one batch of soil that was relatively homogeneous. Hence, if an LCIC was detected in an earlier sample taken from a different jar, it was probably present in the current sample as well, but it was registering as a non-detect because of some type of interference (perhaps from the jar or from the extraction process for that particular day). Note that such multiple measurements on the same soil were not available for the field samples in the full study. Ignoring non-detects or treating them as if they reflected a concentration of zero would have seriously biased the regression results.

To quantify the relationship between LCIC concentration and extraction holding time, a least-squares regression was performed along with two tests for trend: the usual parametric test for a non-zero slope coefficient (Zar, 1984, page 271), and the nonparametric test for trend based on Kendall's tau (Conover, 1980, page 256). Because the data contained several anomalous observations, the more robust nonparametric tests were used. Table D-3 summarizes the results of the nonparametric tests for trend. In every case where a significant trend was found for one neighborhood and laboratory, it was not significant for the other laboratory.

The results of the holding time study indicate that extending the extraction holding time from 10 days to 30 days did not have a significant effect on the concentrations of LCICs during the full field sample study. It should be noted,

Table D-2
ACTUAL HOLDING TIMES AND OBSERVED CONCENTRATIONS

EDA NEIGHBORHOOD 1

Lab	Extraction Date	Extraction Holding Time	DCB Conc	DCB Flag	TCB Conc	TCB Flag	QCB Conc	QCB Flag	CNP Conc	CNP Flag	BHCA Conc	BHCA Flag	BHCD Conc	BHCD Flag	BHCB Conc	BHCB Flag	BHCG Conc	BHCG Flag
1	10/14/87	1	1.30	G	7.70	G	8.43	G	0.08	G	6.76	G	0.49 *	G	1.14 *	G	10.58	G
	10/14/87	1	1.60	G	10.04	G	11.29	G	0.09	G	8.93	G	1.42	G	17.49	G	1.78	G
	10/14/87	1	1.70	G	10.34	G	11.35	G	0.09	G	8.07	G	0.94	G	15.16	G	1.63	G
	10/19/87	6	1.74	G	11.68	G	12.49	G	0.09	G	13.32	G	1.78	G	23.19	G	2.48	G
	10/19/87	6	1.98	G	12.30	G	13.15	G	0.10	G	13.53	G	1.67	G	22.55	G	2.69	G
	10/24/87	11	1.50	G	9.51	G	11.39	G	0.13	G	9.77	G	1.16 *	G	1.89	G	14.18	G
	10/24/87	11	1.87	G	9.79	G	10.60	G	0.13	G	9.79	G	1.51	G	1.87	G	15.72	G
	10/29/87	16	1.97	G	9.18	G	9.21	G	0.13	G	8.85	G	1.66	G	13.92	G	1.74	G
	11/08/87	26	1.59	G	8.66	G	9.57	G	0.17	G	9.29	G	1.33	G	17.69	G	1.93	G
	11/08/87	26	1.21	G	7.94	G	10.68	G	0.19 *	G	9.90	G	1.23	G	18.30	G	1.85	G
	11/18/87	36	0.82	G	6.08	G	8.61	G	0.10	G	7.81	G	0.92	G	11.39	G	1.65	G
	11/18/87	36	0.58	G	4.05	G	12.47	G	0.08	G	6.60	G	1.13	G	11.06	G	1.84	G
	11/28/87	46	1.42	G	7.77	G	8.85	U	0.15	G	10.68	G	1.59	G	20.94	G	1.83	G
	11/28/87	46	2.17	G	10.08	G	10.21	U	0.12	G	10.04	G	1.25	G	18.64	G	2.05	G
	12/08/87	56	1.06	G	6.90	U	8.60	U	0.09	G	6.83	U	0.86	G	13.56	G	1.34	G
	12/08/87	56	1.21	G	11.77	U	13.50	U	0.10 *	G	14.11	U	1.50	G	29.10	G	2.65	G
	12/18/87	66	1.38	G	8.69	G	11.02	G	0.14	U	10.02	G	1.20	G	12.18	G	1.65	G
	12/18/87	66	1.42	G	10.22	G	11.39	G	0.17	U	10.58	G	1.18	G	1.83 *	B	12.80	B
2	10/14/87	1	1.27	G	10.94	G	13.07	U	0.10	U	11.93	G	1.45	G	17.75	G	2.04	G
	10/14/87	1	2.55	G	18.64	G	17.86	U	0.14	U	15.99	G	2.21	G	29.40	G	2.43	G
	10/14/87	1	1.37	G	10.63	G	12.21	U	0.11 *	U	11.15	G	1.63	G	19.21	G	1.63	G
	10/14/87	1	1.44	G	11.90	G	12.62	G	0.09	B	12.02	G	2.16	G	16.50	G	2.33	G
	10/19/87	6	0.97	G	7.40	G	10.16	U	0.08	U	12.26	G	1.37	G	23.10 *	G	2.27	G
	10/19/87	6	1.34	G	10.14	G	11.65	G	0.20 *	G	13.44	G	1.68 *	G	1.09 *	B	1.65 *	G
	10/24/87	11	0.94	G	7.97	G	10.07	G	0.08 *	G	13.98	G	1.49	G	15.91	G	2.73 *	G
	10/24/87	11	1.10	G	8.41	G	11.10	G	0.09 *	G	12.39	G	1.60	G	13.44	G	2.52 *	G
	10/29/87	16	0.77	G	5.75	G	11.59	G	0.04 *	G	10.56	G	1.84	G	19.72	G	2.18 *	B
	10/29/87	16	1.20	G	8.19	G	11.06	G	0.05 *	G	10.02	G	1.67 *	B	21.91	G	2.17 *	G
	11/18/87	36	1.26	G	7.86	G	13.49	G	0.06 *	G	8.40	G	0.88	G	12.60	U	1.71	G
	11/18/87	36	2.92	G	13.23	G	14.18	G	0.06 *	G	11.99	G	1.39	G	21.42	U	2.46	G
	11/18/87	36	1.26	G	6.47	G	8.39	G	0.08 *	G	8.73	G	0.80	G	19.21	G	1.72	G
	11/18/87	36	0.72	G	5.59	G	8.18	G	0.08 *	G	11.53	G	1.27	G	12.15	U	2.82	G
	12/08/87	56	0.92	G	6.10	G	9.77	G	0.04 *	G	11.86	G	1.06	G	18.48	G	2.28	G
	12/08/87	56	0.93	G	6.70	G	9.64	G	0.05	G	11.03	G	1.36	G	19.19	G	2.50	G
	12/13/87	61	1.31	B	10.18	B	14.77	B	0.04 *	B	15.55	B	2.40	B	37.35	B	3.45	B
	12/13/87	61	0.88	B	5.52	B	8.28	B	0.08 *	B	6.89	B	0.93	B	17.99	B	1.62 *	B
	12/18/87	66	0.92	U	4.96	U	6.13	U	0.06	U	6.11	U	0.94 *	U	7.59 *	U	1.08 *	U
	12/18/87	66	1.22	U	6.53	U	44.80	U	0.07 *	U	13.28	U	0.64 *	U	16.66	U	2.05	U

Table D-2
(continued)

EDA NEIGHBORHODD 2

Lab	Extraction Date	Extraction Holding Time	DCB Conc	DCB Flag	TCB Conc	TCB Flag	QCB Conc	QCB Flag	CNP Conc	CNP Flag	BHCA Conc	BHCA Flag	BHCD Conc	BHCD Flag	BHCB Conc	BHCB Flag	BHCG Conc	BHCG Flag
---	----------	----------	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1	10/14/87	1	0.38	G	0.86	G	1.02	G	0.06	G	0.55	G	0.15 *	G	0.51 *	G	0.36 *	G
	10/14/87	1	0.43	G	0.85	G	0.85	G	0.06	G	0.63	G	0.60	G	0.51 *	G	0.23 *	G
	10/14/87	1	0.42	G	0.72	G	0.67	G	0.06	G	0.45	G	0.13	G	0.42 *	G	0.19 *	G
	10/14/87	1	0.36	G	0.71	G	0.67	G	0.07	G	0.38	G	0.14 *	G	0.37 *	G	0.17 *	G
	10/19/87	6	0.51	G	0.97	G	0.98	G	0.07	G	0.50	G	0.09 *	G	0.53	G	0.21 *	G
	10/19/87	6	0.48	G	0.99	G	0.95	G	0.05	G	0.40	G	0.09 *	G	0.47	G	0.13 *	G
	10/24/87	11	0.42	G	0.65	G	0.66	G	0.10	G	0.46	G	0.14 *	G	0.42	G	0.18 *	G
	10/24/87	11	0.40	G	0.73	G	0.77	G	0.10	G	0.41	G	0.09 *	G	0.36	G	0.16	G
	10/29/87	16	0.56	G	0.78	G	0.84	G	0.10	G	0.46	G	0.07	G	0.37	G	0.09	G
	10/29/87	16	0.49	G	0.74	G	0.76	G	0.10	G	0.49	G	0.19	G	0.38	G	0.09	G
	11/03/87	21	0.44	G	0.66	G	0.83	G	0.10	G	0.35	G	0.07 *	G	0.30	G	0.15	G
	11/03/87	21	0.46	G	0.71	G	0.96	G	0.10	G	0.47	G	0.15 *	G	0.35	G	0.15	G
	11/13/87	31	0.52	G	0.68	G	1.08	G	0.13	G	0.31	G	0.11	G	0.31	G	0.11	G
	11/13/87	31	0.50	G	0.75	G	0.89	G	0.13	G	0.36	G	0.12 *	G	0.31	G	0.09	G
	11/28/87	46	0.61	G	0.79	U	0.77	U	0.10	G	0.56	U	0.15 *	G	0.38	U	0.11	G
	11/28/87	46	0.59	G	0.72	U	0.72	U	0.10	G	0.53	U	0.14	G	0.46	U	0.17 *	G
	12/03/87	51	0.44	G	0.70	G	0.74	G	0.09	G	0.29	G	0.11	G	0.27	G	0.08	G
	12/03/87	51	0.51	G	0.77	G	0.84	G	0.09	G	0.43	G	0.11 *	G	0.35	G	0.11	G
	12/08/87	56	0.41	U	0.64	U	0.71	U	0.11	G	0.32	G	0.09 *	G	0.30	G	0.09	G
	12/08/87	56	0.43	U	0.65	U	0.89	U	0.11	G	0.31	G	0.12	G	0.19	G	0.09	G
2		.	0.31	G	0.78	G	0.84	G	0.06	G	0.45	G	0.08 *	G	0.29	G	0.09 *	G
		.	0.37	G	0.92	G	0.98	G	0.07	G	0.45	G	0.10 *	G	0.44	G	0.06 *	G
	10/14/87	1	0.41	G	1.16	G	1.02	G	0.06	G	0.43	G	0.12 *	G	0.32	G	0.14	G
	10/14/87	1	0.37	G	1.00	G	0.95	G	0.05	G	0.43	G	0.16 *	G	0.44	G	0.11	G
	10/19/87	6	0.33	G	0.53	G	0.50	G	0.05	G	0.27	G	0.09 *	G	0.20	G	0.03 *	G
	10/19/87	6	0.39	G	1.08	G	0.99	U	0.03	U	0.43	G	0.20 *	G	0.32	G	0.06 *	G
	10/19/87	6	0.30	G	0.60	G	0.65	U	0.05	U	0.30	G	0.08 *	G	0.24	G	0.07 *	G
	10/24/87	11	0.37	G	0.98	G	0.98	G	0.05	G	0.50	G	0.33 *	G	0.49	G	0.34 *	G
	10/24/87	11	0.51	G	0.94	G	1.08	G	0.08	G	0.46	G	0.18 *	G	0.34 *	G	0.12	G
	10/29/87	16	0.47	G	0.79	G	1.02	G	0.04 *	G	0.53	G	0.06 *	G	0.67	G	0.13 *	G
	10/29/87	16	0.59	G	0.90	G	1.09	G	0.04 *	G	0.44 *	G	0.05 *	G	0.35 *	G	0.13 *	G
	11/03/87	21	0.39	G	0.95	G	1.04	G	0.06 *	G	0.45	G	0.10 *	G	0.38	G	0.10	G
	11/03/87	21	0.26	G	0.64	G	1.09	G	0.05 *	G	0.34	G	0.09 *	G	0.34	G	0.03 *	G
	11/13/87	31	0.57	U	0.75	G	1.04	G	0.10	G	0.31	G	0.10 *	U	0.31	G	0.07 *	G
	11/13/87	31	0.55	U	0.70	G	0.72	G	0.06	G	0.46	G	0.21 *	U	0.31	G	0.22 *	G
	12/03/87	51	0.46	G	0.91	G	1.00	G	0.05 *	G	0.52	G	0.09 *	G	0.46	G	0.19	G
	12/03/87	51	0.52	G	0.83	G	1.02	G	0.05 *	G	0.50	G	0.19 *	G	0.48	G	0.16 *	G
	12/13/87	61	0.52	B	0.78	B	0.83	B	0.03 *	B	0.42	B	0.08 *	B	0.52 *	B	0.24 *	B

Table D-2
(continued)

12/13/87	61	0.58	B	0.88	B	0.95	B	0.06	B	0.36	B	0.19 *	B	0.46	B	0.09 *	B

---

* denotes that this concentration was reported as a non-detect. The primary ion concentration is shown.

. denotes a missing value.

Table D-3
HOLDING TIME STUDY TESTS FOR TREND BASED ON KENDALL'S TAU

LCIC	Neighborhood	Laboratory	Result of Trend Test	N
1,2-Dichlorobenzene	1	1	0	18
		2	-	16
	3	1	+	18
		2	0	13
1,2,4-Trichlorobenzene	1	1	0	16
		2	-	16
	3	1	0	16
		2	0	15
2-Chloronaphthalene	1	1	0	16
		2	0	11
	3	1	+	20
		2	0	13
1,2,3,4-Tetrachlorobenzene	1	1	0	14
		2	0	12
	3	1	0	16
		2	0	13
Alpha-BHC	1	1	0	16
		2	0	16
	3	1	-	18
		2	0	15
Beta-BHC	1	1	0	17
		2	0	12
	3	1	-	18
		2	0	15

Table D-3
(continued)

LCIC	Neighborhood	Laboratory	Result of Trend Test	N
Gamma-BHC	1	1	0	17
		2	0	15
	3	1	-	20
		2	0	15
Delta-BHC	1	1	0	18
		2	-	15
	3	1	0	20
		2	0	13

+ = a positive trend was indicated at $p < 0.05$ (two-sided)
- = a negative trend was indicated at $p < 0.05$ (two-sided)
0 = no trend at $p < .05$ (two-sided)

however, that holding time effects, even if they had been present, would not have affected the results of the EDA sampling area-comparison area comparisons because the sequence of sample analysis was randomized by the requirement that the laboratories analyze the samples in the order that they were received.

REFERENCES

Conover, W. J. 1980. Practical Nonparametric Statistics. John Wiley & Sons, New York, New York.

Zar, Jerold H. 1984. Biostatistical Analysis. Prentice Hall Inc., Englewood, Cliffs, New Jersey.

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APPENDIX E

Data and Information Systems Development

Appendix E
DATA AND INFORMATION SYSTEMS DEVELOPMENT

The soil assessment for indicator chemicals required that rigid QA/QC standards be observed within a demanding sampling schedule. In addition, the data to be collected for project activities were complex and voluminous. To meet the QA/QC and data handling requirements, it was necessary to provide automated support to the project where possible.

Development of the data and information systems built upon the experience and software developed during the pilot study and the soil assessment for dioxin. In addition, a functional requirements analysis provided a software requirements summary and a data flow diagram (see Figure E-1). The systems needed to support the study were designed using the existing soil pilot study software, the dioxin sample tracking software, and the software requirements summary developed for this study.

Ten separate software systems were used, eight were implemented on personal computers and two were implemented on the EPA mainframe system. East of use and the editing capabilities to identify invalid data and prevent illogical functions were high priorities in the development of virtually all of the systems. A system flow chart depicting nine of these systems is presented in Figure E-2. The tenth system (not shown) was a model data base implemented on the mainframe. Each system is described in Table E-1.

The final integrated data base is maintained as a Statistical Analysis System (SAS) relational data base. SAS was chosen because it can handle large quantities of data because it provides extensive data manipulation, merging, reporting, and statistical analysis capabilities. The data base consists of six files, or tables, each containing the key fields required to merge or join each table to any related table. The tables are as follows:

1. Initial Calibrations--Contains one entry for each five-point initial calibration and EPA performance check run on the GC/MS/SIM; and includes all quantitation reports and computed data for an initial calibration.

2. Continuing Calibrations--Contains one entry for each continuing calibration/performance check analysis and the mid-analytical run continuing calibration/performance check analysis for each analytical run and includes all quantitation reports and computed data for the calibrations.

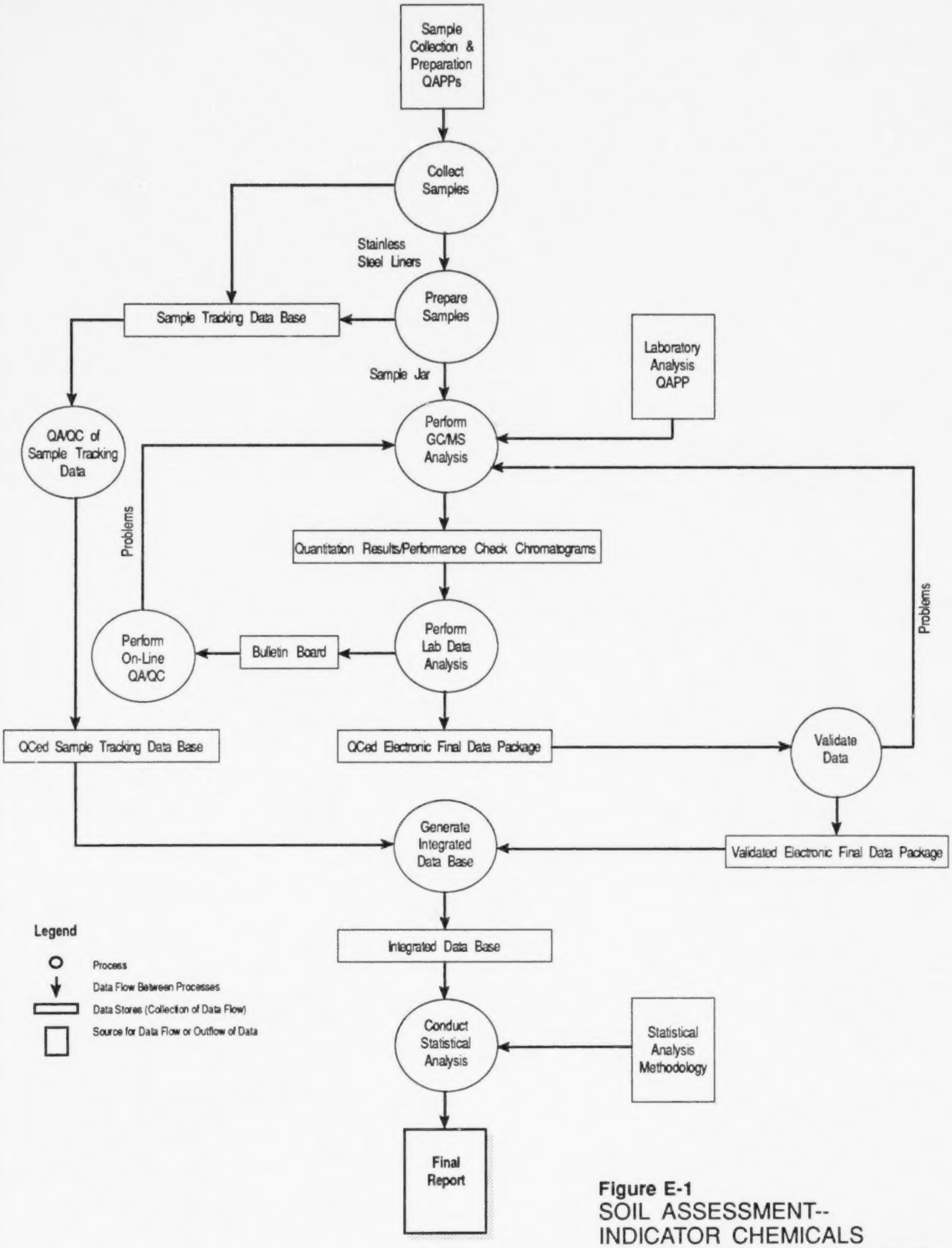
Sample Collection & Preparation QAPPs
Collect Samples
Stainless Steel Liners
Prepare Samples
Sample Tracking Data Base
Laboratory Analysis QAPP
Sample Jar
QA/QC of Sample Tracking Data
Perform GC/MS Analysis
Problems
Quantitation Results/Performance Check Chromatograms
Problems
Perform On-Line QA/QC
Bulletin Board
Perform Lab Data Analysis
QCed Sample Tracking Data Base
QCed Electronic Final Data Package
Validate Data
Generate Integrated Data Base
Validated Electronic Final Data Package
Legend
Process
Data Flow Between Processes
Data Stores (Collection of Data Flow)
Source for Data Flow or Outflow of Data
Integrated Data Base
Conduct Statistical Analysis
Statistical Analysis Methodology
Final Report

Figure E-1
SOIL ASSESSMENT--
INDICATOR CHEMICALS
INFORMATION ENVIRONMENT
DATA FLOW DIAGRAM

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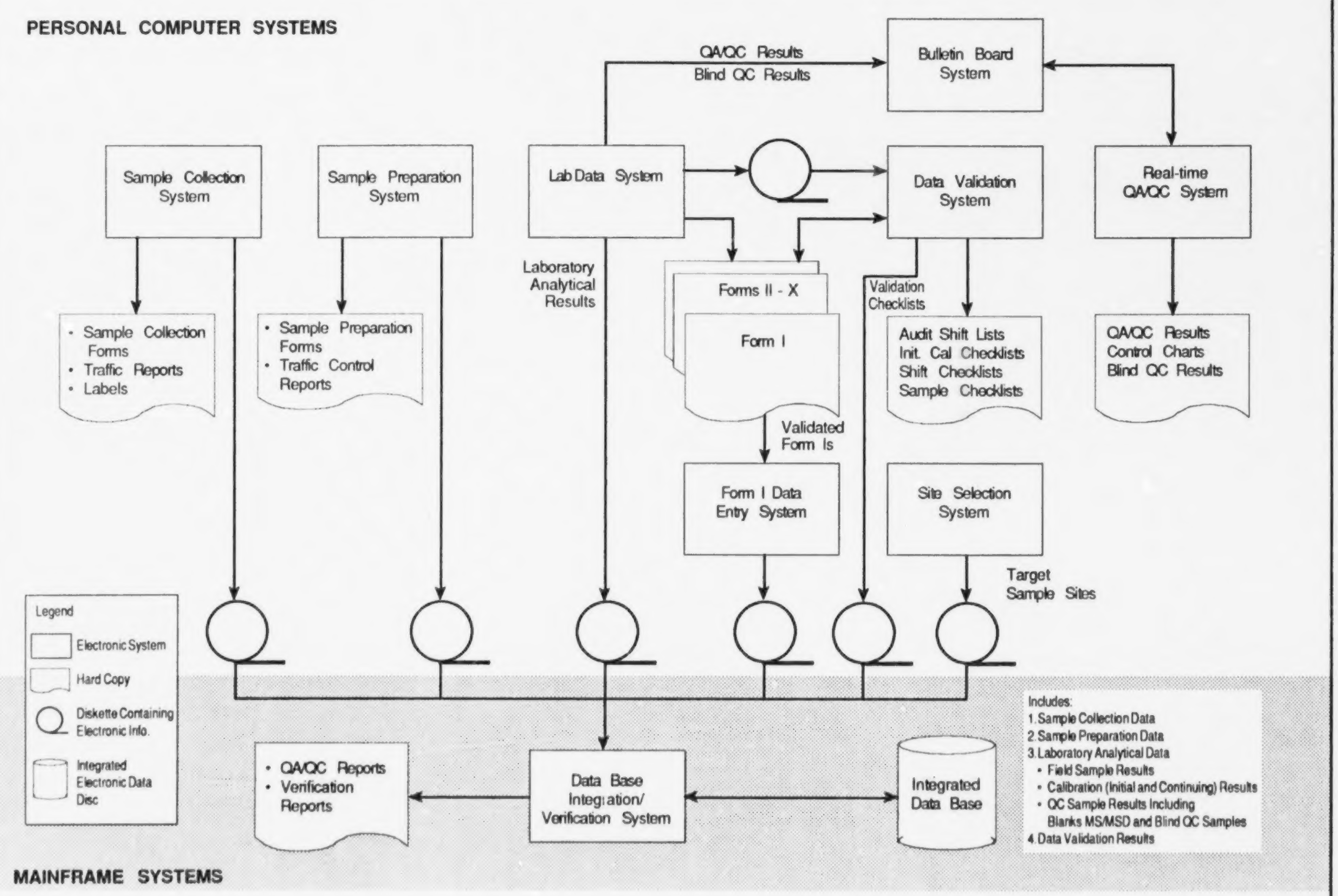
PERSONAL COMPUTER SYSTEMS
QA/QC Results
Blind QC Results
Bulletin Board System
Sample Collection System
Sample Preparation System
Lab Data System
Data Validation System
Real-time QA/QC System
Laboratory Analytical Results
Forms II - X
Form I
Validation Checklists
• Sample Collection Forms
• Traffic Reports
• Labels
• Sample Preparation Forms
• Traffic Control Reports
Audit Shift Lists
Init. Cal Checklists
Shift Checklists
Sample Checklists
QA/QC Results
Control Charts
Blind QC Results
Validated Form Is
Form I Data Entry System
Site Selection System
Target Sample Sites
Legend
Electronic System
Hard Copy
Diskette Containing Electronic Info.
Integrated Electronic Data Disc
• QA/QC Reports
• Verification Reports
Data Base Integration/ Verification System
Integrated Data Base
Includes:
1. Sample Collection Data
2. Sample Preparation Data
3. Laboratory Analytical Data
• Field Sample Results
• Calibration (Initial and Continuing) Results
• QC Sample Results Including Blanks MS/MSD and Blind QC Samples
4. Data Validation Results
MAINFRAME SYSTEMS

Figure E-2
SOIL ASSESSMENT--INDICATOR CHEMICALS INFORMATION MANAGEMENT SYSTEMS

Table E-1
SOFTWARE SYSTEMS DEVELOPED AND USED IN THE
SOIL ASSESSMENT FOR INDICATOR CHEMICALS

System Name	Description
Site Selection	Generates random selection of sample locations on EDA grid and comparison area grid maps
Sample Collection	Generates forms and labels for field sampling; collects completed forms (via double-data entry and comparison); verifies data; and produces reports on tracking/collection status
Sample Preparation	Generates and tracks sample preparation forms; automatically generates the project sample identification number and indicates sample splits and target matrix spike/matrix spike duplicate (MS/MSD) samples; edits and verifies data entered on forms; and produces labels and reports on preparation data status
LabData	Generates sample analysis data reporting forms; performs chromatogram performance check analyses; provides automatic interface with project Online QA/QC System; generates the electronic final data package; and provides automatic interface with the project Data Validation System
Online QA/QC	Produces QC reports on samples being analyzed in the project laboratories on a real-time basis; and produces daily control charts for selected QC data
Data Validation	Interfaces with LabData and automatically displays analytical results to be reviewed, including shift files and calibration; provides data entry for validation checklists; and provides error and status reports

Table E-1
(continued)

System Name	Description
Form I Data Entry	Collects and verifies the Form I's (data reporting form containing LCIC concentrations) validated by EMSL-LV, including the data validation and usability flags assigned; and generates a file for uploading to the mainframe data base
Integrated Model Data Base	Provides a model SAS data base with selected fields filled with data using distributions from the pilot study
Integrated Data Base	Integrates the data generated from the LabData, Sample Collection, Sample Preparation, Data Validation, and Form I Data Entry systems into a mainframe SAS data base; recalculates all data reported on the LabData forms; checks for data consistency between the systems where the same data were available from more than one source; and reports discrepancies or omissions
Project Bulletin Board	Provides an interface between project systems and project staff

3. Field Samples--Contains one entry for each field sample and contains all sample collection, preparation, and analysis data for the sample. The analysis data include all quantitation report and computed data for the sample analysis. Pointers, or keys, join each sample's initial calibration entry, continuing calibration entry, method/holding blank entry, MS and MSD entries (if any), Form I entry, and blind QC entry.

4. QC Samples--Contains one entry for each QC sample; contains all sample collection, preparation, and analysis data for the sample. The analysis data include all quantitation report and computed data for the sample analysis.

5. Form I--Contains one entry for each Form I (the data reporting form containing the LCIC concentrations) validated by EMSL-LV. Each entry contains all Form I data plus extract data and all EMSL-LV data validation and useability flags.

6. Blind QC Spike Levels--Contains one entry for each blind QC sample sent to the analytical laboratories by EMSL-LV. Each entry includes the spiking levels for each analyte spiked into the sample.

The data base included approximately 1.8 million data cells (the number of fields per table times the number of occurrences). Virtually every piece of data generated during the project is included.

APPENDIX F
QA/QC Program

Appendix F
QA/QC PROGRAM

INTRODUCTION

The QA/QC measures for this study consisted of a detailed and extensive system of quality control for samples, procedures, and documentation designed to demonstrate that a high level of quality had been maintained during every aspect of the project. Operationally, the study implementation was divided into four phases: field sampling, laboratory analysis, information management, and statistics. Associated with each of these phases were two types of QA/QC measures: quantitative and qualitative. Quantitative QA/QC measures consisted of specific QC samples and activities designed to demonstrate that the QA/QC objectives were being met. Qualitative QA/QC measures consisted of sufficient documentation to demonstrate that the qualifications of participants were acceptable, that all procedures were being followed, and that the integrity of samples and information was being maintained.

Figure F-1 shows the flow of activities for the four phases of the project and the QA/QC responsibilities associated with each study activity. Primary QA/QC responsibility rested with the CH2M HILL project team. The TRC agencies provided review and guidance throughout the project. The EPA Environmental Monitoring Systems Laboratory at Las Vegas (EMSL/LV) performed an active QA/QC oversight role.

For the laboratory phase of the project, the subcontractor laboratories assumed major QA/QC responsibility, with oversight from both the CH2M HILL team and the EMSL/LV.

FIELD QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

The field QA/QC program involved specific entities for which acceptability could be assessed quantitatively against a QC criterion, as well as more qualitative documentation and procedures designed to show that the data obtained in the study corresponded correctly to the samples obtained in the field. Quantitative and qualitative QA/QC are discussed separately below. Figure F-1 shows the flow of activities in the field and the associated quantitative and qualitative QA/QC measures.

QUANTITATIVE FIELD QA/QC

A major element in the quantitative field QA/QC procedures was to interject blank (theoretically zero concentration) samples at various stages in the sample collection and

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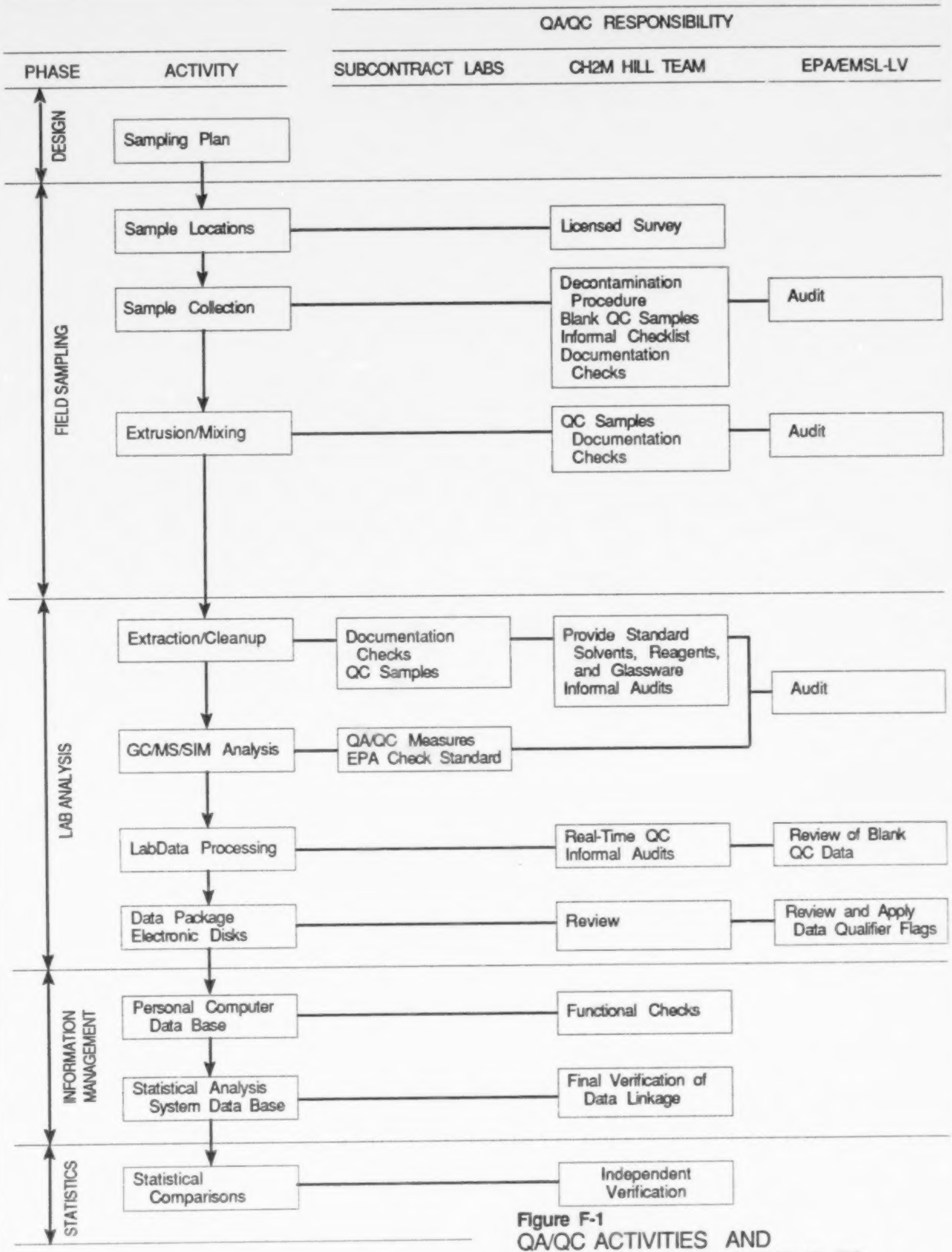

QA/QC RESPONSIBILITY
PHASE
ACTIVITY
SUBCONTRACT LABS
CH2M HILL TEAM
EPA/EMSL-LV
DESIGN
Sampling Plan
FIELD SAMPLING
Sample Locations
Licensed Survey
Sample Collection
Decontamination Procedure
Blank QC Samples
Informal Checklist
Documentation Checks
Audit
Extrusion/Mixing
QC Samples
Documentation Checks
Audit
LAB ANALYSIS
Extraction/Cleanup
Documentation Checks
QC Samples
Provide Standard Solvents, Reagents, and Glassware
Informal Audits
Audit
GC/MS/SIM Analysis
QA/QC Measures
EPA Check Standard
LabData Processing
Real-Time QC
Informal Audits
Review of Blank QC Data
Data Package
Electronic Disks
Review
Review and Apply Data Qualifier Flags
INFORMATION MANAGEMENT
Personal Computer Data Base
Functional Checks
Statistical Analysis System Data Base
Final Verification of Data Linkage
STATISTICS
Statistical Comparisons
Independent Verification

Figure F-1
QA/QC ACTIVITIES AND RESPONSIBILITIES RELATIVE TO PROJECT PHASES

laboratory analysis sequence. The analysis of blank samples provided a measure of contamination sources, decontamination efficiency, and other potential biases that might have been introduced from sources other than the sample. Blanks for soil samples consisted of soil that approximated the consistency of Emergency Declaration Area (EDA) soil and had been prepared and analyzed for the presence of Love Canal Indicator Chemicals (LCICs). (See CH2M HILL, 1987a for more details on the field QC samples.)

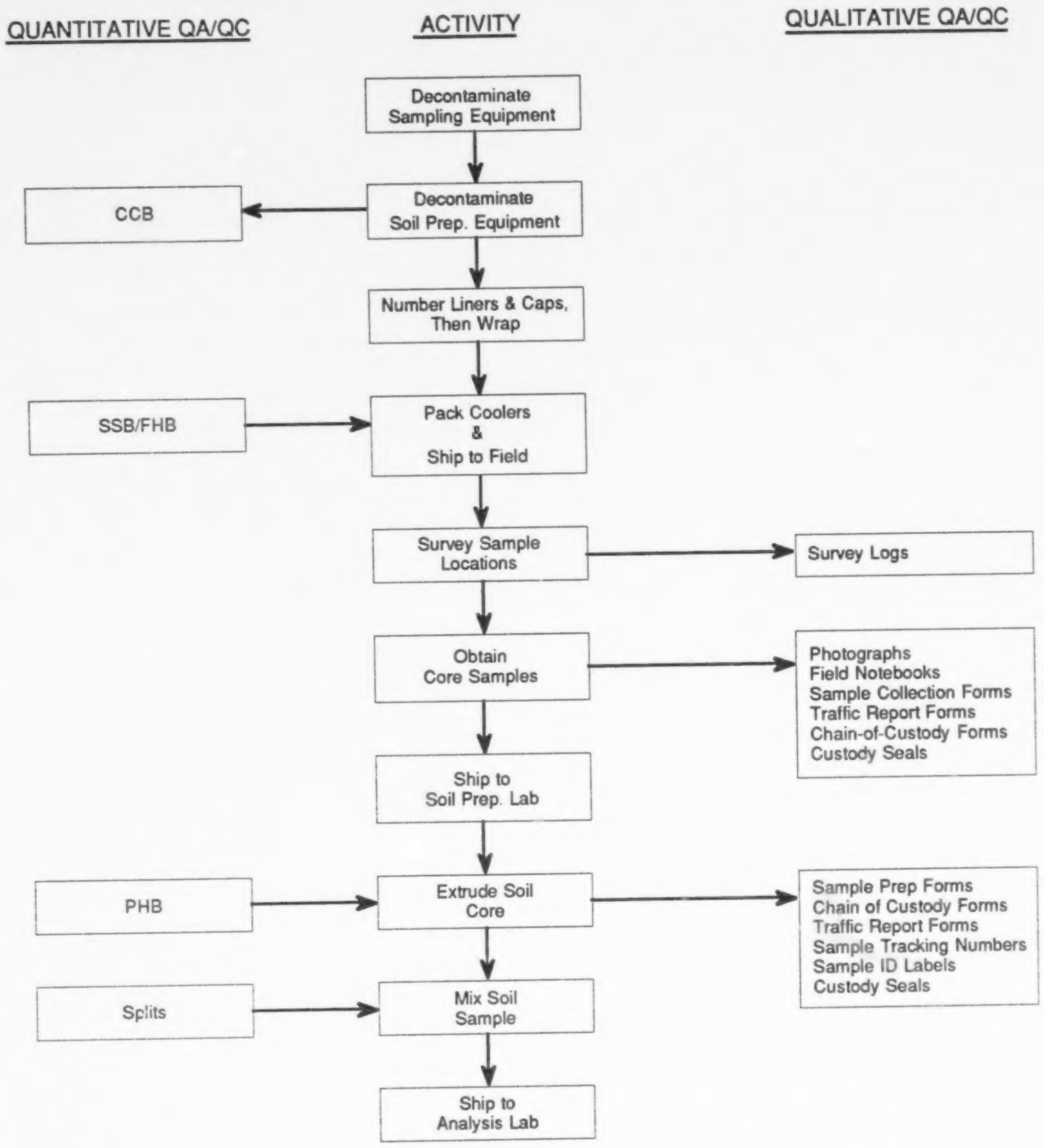
Sample container cleaning blanks (CCBs), sample shipping and storage blanks (SSBs), field handling blanks (FHBs), and sample preparation handling blanks (PHBs) were used to check the integrity of field and preparation laboratory sample handling. Figure F-2 shows the points in the sampling process at which each type of blank was inserted. The sample collection and preparation QAPP (CH2M HILL, 1987a) identifies the collection frequency of each type of field blank sample.

In general, at each step in the field sampling and preparation process where contamination could be introduced, a blank was inserted into the sample stream. Only the FHBs were routinely analyzed. If any contamination had been observed in the FHBs, the other types of field blanks would have been analyzed to isolate the source of contamination.

A sample CCB was taken after each batch of equipment (which included liners, caps, spoons, and spatulas) was cleaned. Additional CCBs were taken so that the total number of CCBs represented at least 5 percent of the items cleaned. If LCIC contamination was detected, the equipment associated with the contaminated CCB was recleaned and another CCB was taken and analyzed.

FBHs were used to detect any contamination from the sampler or from handling of the liner in the field. A container that was certified as clean from the CCB procedure was filled with the blank soil at Cambridge Analytical Associates (CAA), sealed with custody tape, and shipped to the field. The FHB was collected by inserting the sampler into the filled container. It was then handled as a regular sample going through the sample preparation process. The FHB was the only blank that was always analyzed. If any LCICs were detected in an FHB, all other blanks associated with samples taken after the last "clean" FHB, such as SSBs and PHBs, also were analyzed.

SSBs were used to indicate if there was any contamination during shipment from CAA to the field office, during storage in the field office, during shipment from the field to the sample preparation laboratory, or during shipment from the preparation laboratory to the analytical laboratory. At the


QUANTITATIVE QA/QC
ACTIVITY
QUALITATIVE QA/QC
Decontaminate Sampling Equipment
CCB
Decontaminate Soil Prep. Equipment
Number Liners & Caps, Then Wrap
SSB/FHB
Pack Coolers & Ship to Field
Survey Sample Locations
Survey Logs
Obtain Core Samples
Photographs
Field Notebooks
Sample Collection Forms
Traffic Report Forms
Chain-of-Custody Forms
Custody Seals
Ship to Soil Prep. Lab
PHB
Extrude Soil Core
Sample Prep Forms
Chain of Custody Forms
Traffic Report Forms
Sample Tracking Numbers
Sample ID Labels
Custody Seals
Splits
Mix Soil Sample
Ship to Analysis Lab

Abbreviations

CCB	Container Cleaning Blank
FHB	Field Handling Blank
PHB	Preparation Handling Blank
SSB	Shipping and Storage Blank

Figure F-2
SOIL ASSESSMENT - - INDICATOR CHEMICALS
SCHEMATIC REPRESENTATION
OF THE FIELD QA/QC PROGRAM

analytical laboratories, the samples were stored at 4°C for use if the FHB, described above, was contaminated. (If contamination was found in the FHB, and analysis of the corresponding SSB indicated contamination, the analytical results from the field samples corresponding the the SSB were flagged before use in the data analysis.)

PHBs were used to detect possible contamination in the sample preparation process. Several liners were filled with reference soil, capped, sealed, wrapped in aluminum foil, and then sent to the sample preparation laboratory, where they were prepared before being sent to the analytical laboratories for storage.

The PHB was the last sample prepared each day. It was shipped with the other samples and blanks to the analytical laboratories and stored at 4°C. At least one PHB was kept in the preparation laboratory's storage area for the duration of the project and sent directly to CAA for analysis without undergoing any sample preparation other than being placed in the appropriate vial or jar. This blank indicated if any contamination occurred in sending the PHBs to the preparation laboratory or during storage there.

An element of the field QA/QC procedure was to divide field samples into two parts, called "splits," at the preparation laboratory. These splits were designed to measure variability within and between laboratories.

QUALITATIVE FIELD QA/QC

Documentation of the status of collected samples was maintained in a series of report forms, log books, and computerized data management systems. At each step in the process the correctness of information was verified and discrepancies were corrected. The daily soil sampling collection report from the software system was checked against the sample collection form to verify accuracy of the data base in terms of information supplied. Errors, when detected, were noted on the daily report for correction. If errors were detected, corrections were made to the data base, and a new report was generated.

The surveyor's daily report was checked to determine sampling locations that needed to be moved more than 10 feet. The reason for moving locations (e.g., a driveway) was noted in the field team manager's log and in the surveyor's notes. The street address and location descriptor appearing on the surveyor's daily report was compared with the information appearing on the daily sampling schedule. Discrepancies were resolved, when possible, by examining a map. A possible discrepancy might include the term "backyard" versus the term "north side," for example. Discrepancies concerning street addresses or whether a sample was on a property boundary required further review. Documentation changes that could be made at this stage were marked on the daily sampling schedule. Locations sampled were checked against a copy of the map and plotted using actual coordinates supplied by the surveyors. Discrepancies were resolved using photographic and/or field verification.

In the soil preparation laboratory, most of the documentation was generated by the preparation laboratory's personal computer software. When coolers of samples were received, the temperatures inside the coolers were recorded. The contents of each cooler were manually verified by checking the numbers on the liners against the chain-of-custody form. In addition, the sample tracking numbers on the liners were checked against the numbers on the traffic report form. As each liner was extruded, the soil preparation form for that sample was completed, signed, and dated by the sample preparer. The computerized record of sample preparation was completed by entering the station number for that sample into the personal computer software. The computer then generated the identification number for that sample, the analysis laboratory to which the sample was to be sent, and whether the sample was to be a split sample. At the end of each day, the software generated the chain-of-custody forms and traffic report forms to be shipped with the samples to each analytical laboratory. The information on these forms was verified manually against the contents of the cooler before the coolers were shipped to the analytical laboratories.

In addition to the forms described above, the soil preparation laboratory personnel kept a sample preparation log book and refrigerator log books. Details on the preparation laboratory operation are contained in the soil sample collection and preparation QAPP (CH2M HILL, 1987a).

ANALYTICAL QA/QC PROGRAM

The following description of the analytical QA/QC program has been organized into three major parts. The first section describes the pre-implementation laboratory QA/QC program, which consisted of activities conducted before field sampling began. The second section describes the laboratory QA/QC program that was implemented during the field samples analysis; in this section, laboratory QA/QC measures, the real-time laboratory QA/QC program, and the onsite laboratory evaluation/audit are described. The third section describes the post-implementation QA/QC program, which included the data assessment procedures used by the EMSL-LV to examine the quality of the laboratory results.

PRE-IMPLEMENTATION LABORATORY QA/QC PROGRAM

Laboratories were selected and qualified for sample analysis through a sequence of activities designed to result in a laboratory operation that could meet the demanding QA/QC requirements and time constraints of the project. A solicitation of 20 laboratories participating in EPA's Contract Laboratory Program (CLP) resulted in 13 laboratories submitting statements of qualifications. These laboratories were evaluated in four areas: general, Small Business Administration status, EPA CLP performance evaluation audit, and price. The seven laboratories identified for further consideration were audited by the contractor and also received two performance evaluation (PE) samples for analysis. The laboratories were ranked on the basis of the PE and onsite audit results. Once contractual matters were negotiated with the laboratories, five were brought under contract; two additional laboratories also participated in the study: the prime contractor's laboratory and a subcontractor laboratory that had participated in the method development, method validation, and pilot study.

Several training activities were conducted so that the laboratories would be familiar with the details of the analytical procedure. A week-long training session was conducted for the project managers and extraction specialists from the laboratories. The training included classroom discussion, a laboratory demonstration of the soil extraction and cleanup procedure, and a series of laboratory sessions during which the extraction specialists processed matrix spike and method/holding blank (MHB) samples. The extracts were analyzed using the gas chromatograph/mass spectrometer/selected ion monitoring (GC/MS/SIM) protocol, and the results were examined to decide whether further practice and evaluation were required. While the extraction specialists were processing samples, the project managers met with representatives from the EMSL-LV and the prime contractor to discuss the statement of work.

At the conclusion of the training session, the laboratories were provided with a videotape of the sample extraction and cleanup process to be used for in-house training. The laboratories also were provided with two practice samples for their in-house training.

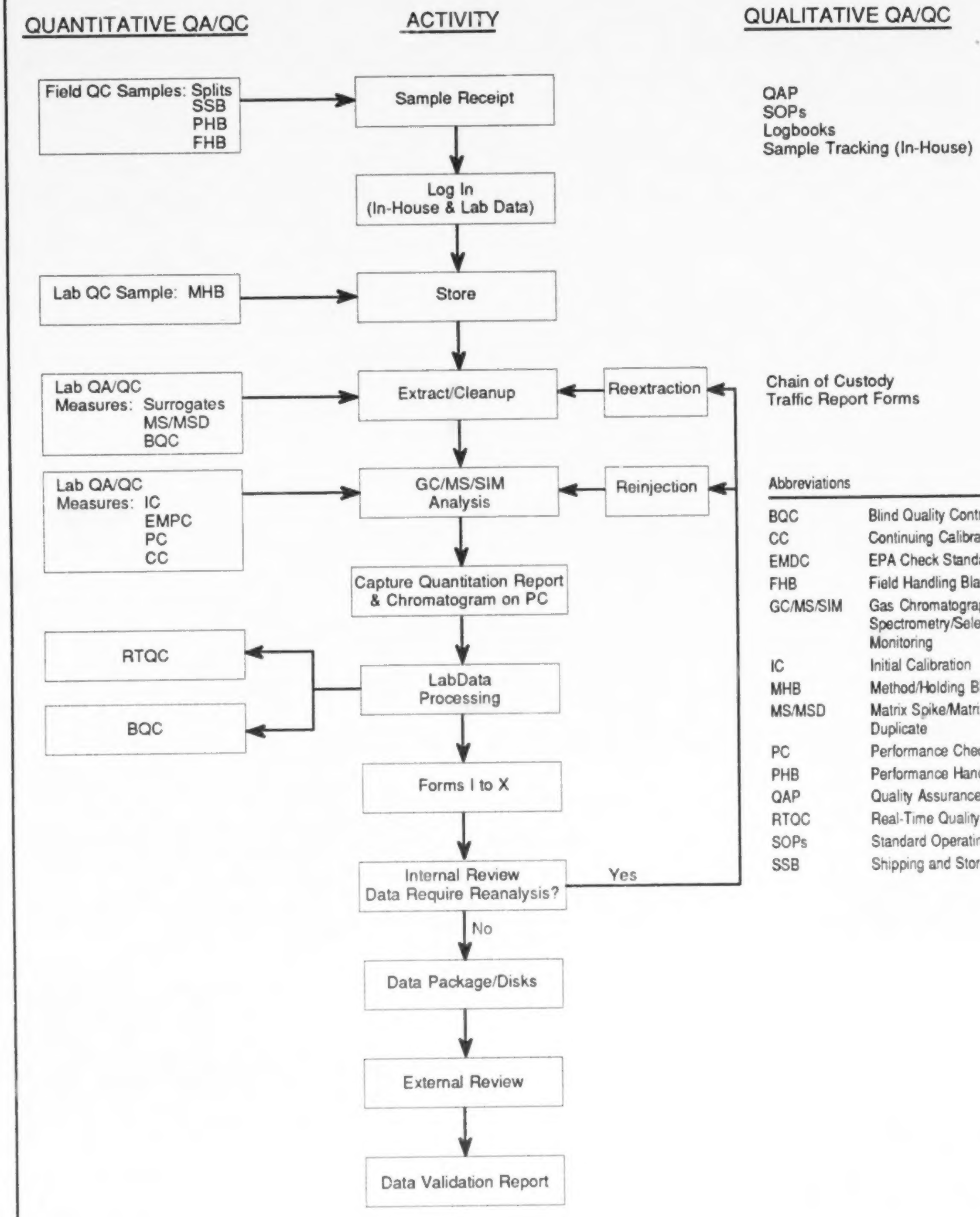
For the laboratories to produce comparable results, they were provided with materials and supplies judged on the basis of the pilot study experience to be of critical importance. All LCICs, surrogate, and internal standards used in the sample analysis were provided by the EMSL-LV. The laboratories also were provided with most of the solvents and reagents used in the sample preparation and analysis procedures. These materials were from single-production lots that were dedicated to the project and were demonstrated by extensive QC analysis to have acceptably low levels of LCICs or LCIC interferences. In addition, specialty glassware for the sample preparation and cleanup was provided. This included the Snyder distillation columns (micro and macro) and the silica chromatography columns.

The primary responsibility for record keeping and documentation rested with the analytical laboratory. This process began with the laboratories preparing quality assurance plans (QAP) describing their QA/QC system and the qualifications and responsibilities of the personnel involved with the project. Part of each QAP included series of standard operating procedures (SOPs) that detailed the specific sequence of activities to be used on the project. Both the QAP and the SOPs were submitted to the prime contractor for review and were made available to auditors during onsite laboratory audit.

PE samples were used to demonstrate that the laboratories had become sufficiently proficient with the method to allow field sample analysis to proceed. This sample analysis program is described in greater detail in Appendix B. The PE samples were prepared by the EMLS-LV using blank homogenized soil similar to that found at Love Canal. The first set of PE samples consisted of four samples whose concentrations were known and one sample whose concentration was unknown to the laboratories. The laboratories were required to analyze these five PE samples in duplicate. In order to assess the analytical proficiency of the laboratories, the data from the first set of PE samples were used to evaluate the method detection limit and to establish acceptance windows for the blind QC (BQC) samples. The statistical analysis on the first set of PE data produced windows that were excessively wide. Once the laboratories had taken corrective actions, a second set of PE samples was analyzed. The results of this set of analyses were acceptable, indicating that the laboratories were ready to analyze field samples.

IMPLEMENTATION LABORATORY QA/QC PROGRAM

A number of laboratory QA/QC requirements were used during the sample analysis in order to more closely monitor the quality of the data and to provide assurance that the analytical system was in control at all times. A schematic representation of the laboratory QA/QC program is shown in Figure F-3. This figure relates the specific laboratory activities to the quantitative and qualitative QA/QC measures. The laboratory QA/QC program (e.g., laboratory QA/QC measures, real-time laboratory QA/QC program, and onsite laboratory evaluation/audit) that was implemented during the sample analysis is described below.


QUANTITATIVE QA/QC
ACTIVITY
QUALITATIVE QA/QC
Field QC Samples: Splits
SSB
PHB
FHB
Sample Receipt
QAP
SOPs
Logbooks
Sample Tracking (In-House)
Log In
(In-House & Lab Data)
Lab QC Sample: MHB
Store
Lab QA/QC
Measures: Surrogates
MS/MSD
BQC
Extract/Cleanup
Reextraction
Chain of Custody
Traffic Report Forms
Lab QA/QC
Measures: IC
EMPC
PC
CC
GC/MS/SIM
Analysis
Reinjection
Capture Quantitation Report
& Chromatogram on PC
RTQC
BQC
LabData
Processing
Forms I to X
Internal Review
Data Require Reanalysis?
Yes
No
Data Package/Disks
External Review
Data Validation Report

Abbreviations

BQC	Blind Quality Control Sample
CC	Continuing Calibration
EMDC	EPA Check Standard
FHB	Field Handling Blank
GC/MS/SIM	Gas Chromatograph/Mass Spectrometry/Selected Ion Monitoring
IC	Initial Calibration
MHB	Method/Holding Blank
MS/MSD	Matrix Spike/Matrix Spike Duplicate
PC	Performance Check
PHB	Performance Handling Blank
QAP	Quality Assurance Plan
RTQC	Real-Time Quality Control
SOPs	Standard Operating fProcedures
SSB	Shipping and Storage Blank

Figure F-3
SOIL ASSESSMENT - - INDICATOR CHEMICALS
SCHEMATIC REPRESENTATION
OF THE LABORATORY QA/QC PROGRAM

Laboratory QA/QC Measures

Within each laboratory, all QA/QC measures equivalent to those of the EPA CLP were used, including matrix spikes (MSs), matrix spike duplicates (MSDs), laboratory MHBs, initial calibration (IC) standards, EPA check (CC) standards, PC standards, continuing calibration standards, surrogate standards, internal standards, and BQC samples. In addition to these QA/QC measures, a concept of the analytical run was used for both extraction batches and instrument analysis batches. An extraction batch consisted of up to 10 field samples or matrix spike samples plus a BQC sample and a laboratory MHB. An instrument analysis batch consisted of an initial combined PC/CC standard, a MBH, BQC sample or check standard, field samples, and an ending PC/CC standard. According to this concept, the QA/QC samples, e.g., MHB, MS/MSD, and BQC, that were extracted with field samples in the same batch would also be analyzed with them. This would provide a block of analytical data from the extraction and analysis batches with evidence that the analytical system was in control.

Another feature of the QA/QC program is the use of either a 12-hour or a 16-hour analysis sequence. The laboratories had the option of choosing one analytical sequence. The use of a 16-hour analytical sequence with a PC/CC standard in the middle of the run was allowed to make the analytical run compatible with the number of samples in an extraction batch. The 16-hour run enabled the laboratories to increase sample throughput with no decrease in the quality of the data. More detailed information about these QA/QC measures can be found in the sample analysis QAPP (CH2M HILL, 1987b). The following describes briefly these QA/QC measures.

Before any sample analysis, the laboratories were required to analyze a PC standard to demonstrate adequate GC and MS resolution and sensitivity and mass range calibration. A PC standard solution contains LCICs, surrogate standards, internal standards, and 1-chloronaphthane. Also, a reagent blank (RB) was used to demonstrate that samples could be brought through the sample preparation and analysis process without being contaminated by LCICs and LCIC interferences.

After the criteria for the PC standard solution were met, an IC containing LCICs and surrogate standards was performed using a minimum of five concentrations to determine the linearity of response using the LCICs. The analytical laboratories then analyzed the EPA check standard and compared it to the IC standards whenever ICs were performed and, in any event, every 2 weeks. The EPA check standard analysis was used to validate the accuracy of the IC curve by comparison with a solution of known concentration prepared by EMSL-LV (thus eliminating possible bias in the laboratory preparation of standards).

A continuing calibration PC (CC/PC) standard containing LCICs and surrogate standards was performed at the beginning and the end of each analytical run during sample analysis. The relative response factors from the CC/PC analyzed at the beginning of the run were compared with the average relative response factors from the initial calibration for the GC/MS instrument. The difference was required to be less than 25 percent (30 percent for delta-BHC). If the difference exceeded the criteria an initial calibration was required. Both the CC/PCs analyzed at the beginning and the end of the analytical run were evaluated to demonstrate adequate GC and MS resolution, sensitivity, and mass range calibration.

All samples were spiked with surrogate standards (compounds of know concentration that eluted from the GC column at retention times similar to those of LCICs) immediately before extraction. Compounds used as surrogate standards were 1,4-dibromobenzene, 2,4,6-tribromobiphenyl, and 1,2,4,5-tetrabromobenzene. A surrogate spike analysis was used to indicate the recovery of the analytical process (e.g., extraction and analysis).

For each extraction batch (not to exceed 10 or fewer field samples), a laboratory MHB was analyzed to check for any background contamination from the laboratory. A laboratory MHB, which is a blank sand sample provided by EMSL-LV, was placed in the refrigerator at the same time that a batch of field samples was received. If contamination was detected at levels exceeding those specified, the cause was determined and corrective actions were taken before proceeding with sample analysis.

BQC samples provided by EMSL-LV were analyzed at a frequency of one per extraction batch to assess the recovery of the analytical method. EMSL-LV prepared the BQC samples by adding an amount of LCICs, which was known to EMSL-LV but unknown to the laboratories, to a sample of specially prepared soil. The results of this analysis were used to estimate the bias and variability of the analytical process at each laboratory.

In addition to the laboratory MHB and BQC sample, an MS/MSD sample was extracted and analyzed at a frequency of one set per 20 samples to assess the precision and accuracy of the analytical method. The MS/MSD sample was prepared by spiking with 5.0 ppb of LCICs to two separate sample aliquots of one field sample.

After the samples were extracted, the extracts were spiked with the internal standards immediately before final concentration to final volume of 100µl. The internal standards for GC/MS analysis were D4-1,4-dichlorobenzene, D8-naphthalene, D10-acenaphthene, D10-phenanthrene, and D10-pyrene. The internal standards were used to compensate for variation from nominal values in the final concentration.

The laboratories were required to meet the QA/QC frequency and criteria as described above and in the sample analysis QAPP (CH2M HILL, 1987b). If the required criteria were not met, the laboratories were required to take necessary corrective actions to identify and eliminate the problems. Strict reextraction/reanalysis requirements were implemented if the laboratories did not meet the required criteria after the necessary corrective actions.

Real-Time Laboratory QA/QC Program

The information collected for each analytical run was processed using the instrument's software in conjunction with LabData software, which produced a shift results file and a chromatogram file. The shift results file contained the quantitation report of chromatographic retention times and area counts for each of the ions monitored for each chemical compound (LCICs, surrogate standards, and internal standards). The chromatogram file contained those portions of the PC/CC standards that were needed to assess instrument performance. In addition to these two files, the instrument's software produced the total ion current (TIC) and selected ion current profile (SICP) chromatograms for inclusion in laboratory's data package.

The shift results file and the chromatogram file were then electronically transmitted to a personal computer for further processing. This personal computer executed the study-provided LabData software, a customized package for the soil LCIC study. LabData is described in Exhibit A4 of Appendix A of the sample laboratory analysis QAPP (CH2M HILL, 1987b).

LabData processed the shift results and chromatogram files and then produced draft versions of the data package forms (Forms I to X). These forms were used by the laboratories for internal review of the data. The laboratory-related QA/QC requirements were evaluated by LabData. The draft forms, in conjunction with the SICPs, were used to determine if acceptable sample analysis had been achieved. Samples that were not successfully analyzed were scheduled for reinjection or reextraction as appropriate.

Once the information from sample receipt, sample preparation, and analytical run had been processed through LabData, the QA/QC data from the associated shift file were transmitted (uploaded) to an electronic bulletin board for review.

This real-time QA/QC report contained information on surrogate recoveries, internal standard areas, MS/MSD recoveries, MHB levels, PC and CC standards, and sample status. The real-time QA/QC data were then downloaded by the contractor and EMSL-LV and reviewed using the standard operating procedures described in Appendix C of the sample laboratory analysis QAPP.

The real-time review examined surrogate recoveries, MS/MSD recoveries, internal standard areas and retention times, PC standards, CC response factors, and extraction and analysis holding times. (When these criteria are within the QAPP specified control limits, it is likely that the analytical system of the laboratory is operating in statistical control.) In addition to checking that individual analyses met specifications, the software also accumulated run results into control charts to allow the QA/QC personnel to spot trends in instrument performance.

Part of the real-time QA/QC data was the information on the BQC samples. This information was accessed by EMSL-LV from the bulletin board and was used to evaluate the laboratory's performance. Personnel from EMSL-LV used their own software to access the BQC data and to assess the acceptability of the BQC samples. Once the BQC data had been reviewed, EMSL-LV uploaded to the bulletin board a report indicating the acceptability of the BQC sample. This report was downloaded by the laboratory to confirm the status of that BQC sample. This process is described in more detail in Appendix B of this report.

Other real-time QA/QC procedures performed by the contractor and EPA involved assessing the overall status of a laboratory, as well as the laboratory's success at resolving any difficulties encountered during the project. The Laboratory Technical Manager conducted daily telephone conversations with all laboratories to assess their current situation. The discussions addressed any technical issues that had arisen.

Laboratory Onsite Evaluation/Audit

During the sample analysis, documentation on the status and processing of samples was included in a series of log books that were completed by the laboratory personnel and reviewed periodically by each laboratory's QA staff. The records consisted of sample log-in, extraction, refrigerator storage, and instrument analysis. These records either were included in the data packages or have become part of the laboratory's case file that is sent to the NEIC at the conclusion of the project. The case file contains every written record of information from the project, including sample tags, shipment airbills, and correspondence.

Periodically throughout the study, personnel from the prime contractor, EMSL-LV, and NEIC conducted onsite laboratory evaluation and audits that involved a complete examination of the personnel, facilities, equipment, chain-of-custody procedures, analytical and QA/QC procedures, and documentation records being used by the laboratory. These are discussed in more detail in Appendices G and H.

POST-IMPLEMENTATION LABORATORY QA/QC PROGRAM (DATA VALIDATION)

During the laboratory phase of this study, the laboratories prepared final data packages containing the data for all samples for which complete data had been obtained at that time. LabData was used to produce the final forms that were included in each data package. In addition, LabData produced two sets of floppy disks. One set contained information used by EMSL-LV for data assessment; the other was sent to the prime contractor for use in building the final data base.

EMSL-LV was responsible for providing an independent review of the validity of the data produced by the laboratories during the habitability study. EMSL-LV conducted a data validation and assessment on the final data package. This validation and assessment consisted of an electronic audit of QA/QC data in the final data packages and a review of the hardcopy data packages for quality flaws and verification of the electronic audit. The EMSL-LV data assessment procedure is presented in more detail in Appendix H.

DATA BASE QA/QC PROGRAM

The data base QA/QC program consisted of the following major components:

- QA/QC of project source documents, such as sample collection forms, sample preparation forms, and traffic control forms, to verify that the source documents for the data base were correct.
- QA/QC of software systems that collected, manipulated, and/or generated data that flowed into the data base to verify that data entry was correct and that calculations performed by the software were correct.
- QA/QC of the data loaded into the data base and the data integration process to verify that the data were properly loaded into the correct fields in the data base and that the data linkages, or

connections between the various data fields, were correct.

The data base QA/QC program resulted in a logical approach to storing correct data in the data base. The components also reflected the process through which the data flowed into the data base. To the extent possible, cross-checks were built into the software and QA/QC processes to provide more than one way to check the validity of critical data. The following sections describe each of these components.

SOURCE DOCUMENT QA/QC

The source document QA/QC began with the sample collection forms and traffic report forms. As these forms were completed by field personnel, they were reviewed by supervisory sampling personnel, and the sample collection form was prepared for data entry. Each form was keyed twice by different data entry clerks, and the resulting files were compared. Any discrepancies were investigated and resolved. The samples were then sent to the preparation laboratory.

In the preparation laboratory, the site number of the sample, taken from the previously reviewed traffic report form, was entered into the Sample Preparation System. As part of the sample design, a master table of selected sites (and target coordinates) was prepared. This table was then used by the Sample Preparation System to identify samples being prepared and to automatically generate sample identifiers. The system also automatically (1) indicated which samples may have needed to be screened because they were taken from areas in which high concentrations were found in the pilot study, (2) identified samples to be split and generated the associated identifier to be used, and (3) identified samples to be used as native samples for MS/MSD samples. This automatic generation of data, as well as the sample preparation form and associated traffic report form, substantially reduced the possibility of these data being incorrectly entered on the forms. In addition, the data used to generate the forms were validated before they were entered into the system (i.e., the table driving the system was validated), further reducing the chance that a form would be inaccurate.

Once the sample collection and preparation process was complete, the resulting files were checked to verify the following:

- Sites targeted for sampling were sampled.
- Sites were sampled only once (i.e., no duplicate samples).

- Field samples sent to the preparation laboratory were prepared (except those that could not be extruded) and sent to the analysis laboratory.
- Samples prepared were, in fact, valid samples from a valid collection site.
- Samples were prepared only once (i.e., duplicate samples were not sent to the analysis laboratory).

SOFTWARE SYSTEM QA/QC

Before each software system was placed into operation on an ongoing basis during the project, the functions of each of the systems were validated to verify that data were stored and calculations were performed correctly, and data outputs were checked for accuracy.

For the site selection system, a pattern analysis was used to verify that the randomizing algorithm was not biased in the selection of targeted sites within the boundaries of the selected neighborhood. In addition, it was verified that the spacing between the target sites conformed with the sample design.

For the sample collection system, it was verified that the data entry programs stored the data in the correct fields in the sample collection data base. In addition, the program used in the system to perform the comparison between the two files was checked to verify that the proper fields were compared and that any corrections entered were properly stored in the data base. All reports generated were checked to verify that the reports accurately reflected the data contained in the data base.

For the sample preparation system, it was verified that the system properly retrieved the sample coordinates when given a valid site identification. In addition, it was verified that the system randomly generated a project identification and properly stored the identification with the correct site identification in the sample preparation data base. It was also verified that the system was properly identifying sites for screening. The identification of samples to be split (i.e., the frequency) and the proper storage of the split's project identification were verified as well. The system was checked to verify that it was sending the samples to the appropriate analytical laboratory since the system automatically generated the traffic report form. In addition, all reports were verified to determine that the data contained in the data base were properly reported.

For the LabData system, the verification effort was intensive and complex. This system produced the forms used by the analytical laboratory to report the results of the sample analyses. Data were electronically captured from the GC/MS/SIM; additional data were entered into the system by laboratory personnel. Therefore, QA/QC was performed on every data element on every form to verify that (1) the data were being captured correctly by the LabData system, (2) all calculations were being performed correctly, and (3) the results were being reported properly. This effort was performed at the beginning of the study using the PE samples provided to the laboratories and was performed independently by project personnel and by each analysis laboratory. Periodically, the same PE sample forms were regenerated to verify that the software was still producing the same results. Moreover, calculations were spot-checked to verify their accuracy. In addition to the validation of the forms generation, it was also verified that data were being correctly transmitted by the LabData System to other project software systems. This included the data transmitted to the real-time QA/QC system, data sent to the data validation system, and data generated for upload to the integrated data base.

For the real-time QA/QC system, the software was checked to verify that the data downloaded from the project bulletin board (sent there automatically by the LabData system) were properly stored. The reports and control charts produced by the system were verified to determine that the data depicted on the charts and contained on the reports accurately reflected the data contained in the system data bases.

For the data validation system, the software was checked to verify that data were properly loaded onto the system files. Reports were checked to verify that data contained in the reports accurately reflected data base contents. In addition, the summary concentration report for each laboratory was verified against the Form I's (i.e., matching the reported concentrations) submitted to EMSL-LV for validation. The software was also checked to verify that the data validation checklists entered were properly stored.

The Integrated Data Base Model software was checked to verify that the data being modeled (only a subset of data base fields were filled with data) were correctly stored and that the generated data conformed to the distributions identified in the pilot study.

The Form I Data Entry System software was checked to verify that the program stored the data in the correct fields in the Form I system data base. In addition, the program used to compare the two data entry files was checked to verify that the proper fields were compared, and that any corrections entered were properly stored in the data base.

The QA/QC procedures used for the program that loaded the data generated by the various Love Canal information management systems into the integrated data base, as well as the procedures used to conduct QA/QC procedures and validate the integrated data base, are described in the following section.

INTEGRATED DATA BASE QA/QC

The data base QA/QC process had two components. First, each computer program in the system had to be checked to verify that data were loaded and retrieved correctly and that calculations in the program were being performed correctly. This established a verified system with which to perform the second component of the QA/QC process, which was to verify that the data in the data base were correct and that the various tables in the data base were linked and linked correctly.

The software was verified through the normal process of printing hard copy inputs and outputs from each program and manually verifying that data were correctly handled and calculations were properly performed. Additionally, during the data base load and verification process, the programs were periodically checked to verify that validation errors flagged were not actually software bugs.

Inherent in the design of the system was the need to perform as many of the verification checks as possible using automated means. Thus, most of the programs in the system incorporated checks to verify the data being processed. Figure F-4 depicts a flow chart of the system, and Table F-1 lists the steps in the load and verification process.

STATISTICAL QA/QC

Statistical QA/QC consisted of independent computation and cross verifications of all major statistical analyses. The basic statistical comparisons were programmed in SAS, GAUSS, and FORTRAN in three computer centers by three analysis groups. The results were cross checked and all inconsistencies resolved.

REFERENCES

CH2M HILL. 1987a. Love Canal Habitability Study--Soil Sample Collection and Preparation Quality Assurance Project Plan (Final Revised Version).

CH2M HILL. 1987b. Love Canal Habitability Study--Soil Sample Laboratory Analysis Quality Assurance Project Plan.

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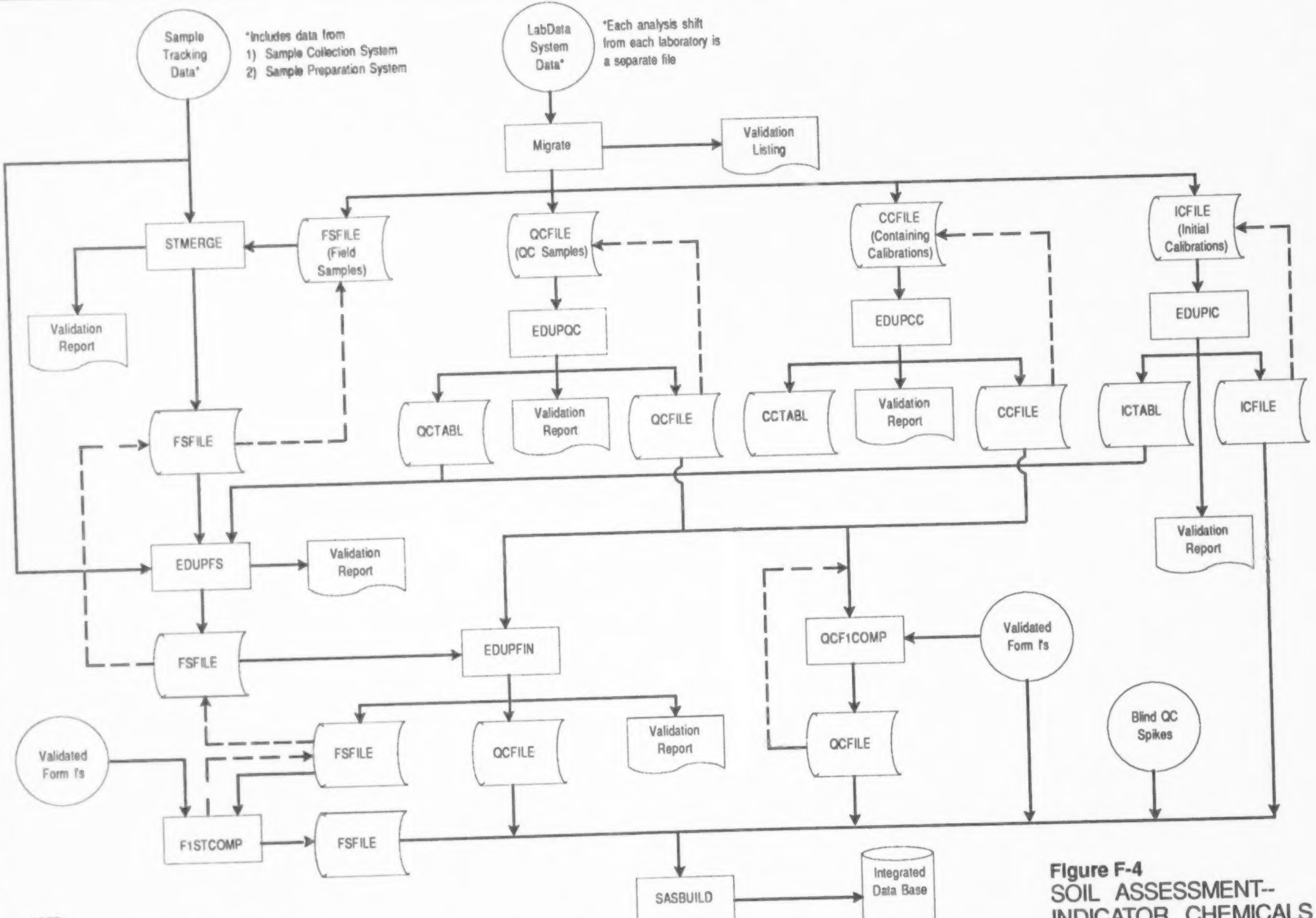
Sample Tracking Data*
*Includes data from
1) Sample Collection System
2) Sample Preparation System
LabData System Data*
*Each analysis shift from each laboratory is a separate file
Migrate
Validation Listing
STMERGE
FSFILE (Field Samples)
QCFILE (QC Samples)
CCFILE (Containing Calibrations)
ICFILE (Initial Calibrations)
Validation Report
EDUPQC
EDUPCC
EDUPIC
FSFILE
QCTABL
Validation Report
QCFILE
CCTABL
Validation Report
CCFILE
ICTABL
ICFILE
Validation Report
EDUPFS
Validation Report
FSFILE
EDUPFIN
QCF1COMP
Validated Form I's
Blind QC Spikes
Validated Form I's
FSFILE
QCFILE
Validation Report
QCFILE
F1STCOMP
FSFILE
SASBUILD
Integrated Data Base

Figure F-4
SOIL ASSESSMENT--
INDICATOR CHEMICALS
INTEGRATED DATA BASE
SYSTEM FLOW CHART

NOTE;
Dashed lines (----) indicate an iterative process, i.e. the output file becomes the input file for the next iteration or execution of the program.

Table F-1
STEPS IN THE LOAD AND VERIFICATION PROCESS

Program Name	Description
1. Validate LabData (manual process)	Using the list prepared by EMSL-LV during the data validation process, each laboratory was visited to verify that its LabData System data conformed to the list. (This list, organized by analysis shift, details all validated analyses, including calibrations and field QC analysis.) After completion of the verification, final data packages for all valid analyses shifts were then generated.
2. Upload Final Data Packages (manual process)	The final data packages, contained on diskettes, were uploaded to the EPA mainframe computer. All files were successfully uploaded.
3. MIGRATE	The MIGRATE program, which separated the LabData data into separate files to be loaded into the integrated data base, was then executed.
4. STMERGE	The program that merged the sample tracking data with the field sample data was executed. The validation report from this program listed any records in sample tracking that did not match to a field sample from the LabData System and vice-versa. All discrepancies were resolved.
5. EDUPQC	This program processed the QC samples and recomputed any results fields, using the original quantitation report data, generated by LabData. Only results fields requiring no data from other quantitation reports (e.g., calibration data) were recalculated. All discrepancies were resolved in fields used to join other table entries.

Table F-1
(continued)

Program Name	Description
6. EDUPIC	This program processed the IC samples and recomputed any results fields, using the original quantitation report data, generated by LabData. All discrepancies were resolved.
7. EDUPCC	This program processed the CC samples and recomputed any results fields, using the original quantitation report data, generated by LabData. Only results fields requiring no data from other quantitation reports (e.g., IC data) were recalculated. All discrepancies were resolved in fields used to join other table entries.
8. EDUPFS	This program processed the field samples and recomputed selected results fields, using the original quantitation report data, generated by LabData. Only results fields requiring no data from other quantitation reports (e.g., calibration data) were recalculated. Sample IDs were verified against the sample tracking data. Edits were performed to verify that the calibration entry for the field sample was in the data base and that any QC samples pointed to by the field sample were also in the data base. All discrepancies were resolved in fields used to join other table entries.
9. EDUPFIN	This program processed the field samples, verifying all fields that require data from multiple sources; it recomputed concentrations, recoveries, etc., and all discrepancies were resolved.

Table F-1
(continued)

	Program Name	Description
10.	FISTCOMP QCSTCOMP	These programs performed a three-level match between the Form I data validated by EMSL-LV and data entered, and the Form I data contained on LabData. The initial match was on the Lab Login identification for the Form I. This was the unique key used by the LabData System to track the sample analysis. Any mismatches were reported. Then, for those samples whose identifications matched, two additional levels were checked. The sample identification (the project identification), analysis date, and analysis time were matched and mismatches reported. Then all LCIC concentrations, percent moisture and dilution factor were compared. Discrepancies between Lab Login IDs were resolved; and validated Form I's linked to a valid LabData entry (which contains all the raw data for the analysis) and all LabData entries linked to a validated Form I.
11.	SASBUILD	This program loaded the validated data files into the integrated data base.

APPENDIX G
NEIC/TechLaw Participation
Soil Assessment--Indicator Chemicals

Prepared by

U.S. EPA National Enforcement Investigation Center
TechLaw, Inc.
Lakewood, Colorado

May 4, 1988

SUMMARY OF NEIC AND CEAT PARTICIPATION IN LOVE CANAL EMERGENCY DECLARATION AREA HABITABILITY STUDY (LCHS) SOIL ASSESSMENT FOR INDICATOR CHEMICALS

In October 1985, the National Enforcement Investigations Center (NEIC) received a request for evidence preparation assistance from the Environmental Protection Agency (EPA) Region II. This request involved work supporting a Pilot Study and Soil Assessment for Indicator Chemicals Study related to the Love Canal hazardous waste site (Superfund Site/Spill Identifier No. 05) in Niagara Falls, New York. The NEIC assigned the Contract Evidence Audit Team (CEAT-TechLaw) to participate in these studies by attending planning meetings, reviewing and commenting on the Quality Assurance Project Plan (QAPP), and performing evidence audits of the field and laboratory operations related to the studies.

The purpose of the CEAT's work effort was to ensure that the evidence collected during the studies was consistent with the NEIC Policies and Procedures manual. The following is a review of the tasks performed by the CEAT to date and a summary of the CEAT's participation in the project and related follow-up activity.

SOIL ASSESSMENT FOR INDICATOR CHEMICALS ORGANIZATIONAL MEETINGS

CEAT personnel attended organizational meetings prior to both the Pilot Study and the Soil Assessment for Indicator Chemicals Study. During these meetings, evidence audit schedules were determined and issues regarding the proper methods of documentation were discussed.

QAPP REVIEW

CEAT personnel reviewed copies of the QAPP and supplied comments to the study project managers. The QAPP was reviewed to determine if the procedures described for sample collection, sample transfer, and documentation of evidence related field and laboratory activities met Evidence Audit Requirements.

FIELD EVIDENCE AUDITS

CEAT personnel conducted two field evidence audits at Love Canal during the LCHS. The first audit was conducted during the Pilot Study, July 15-18, 1986. The second audit was conducted during the Soil Assessment for Indicator

Chemicals Study, October 14-16, 1987. The auditors observed document control and chain-of-custody procedures followed during sample collection, sample preparation, and related data compilation.

Documentation methods were reviewed to determine if the information recorded was complete, consistent, and represented an accurate record of the field sample collection activities. The documents used in the field were audited to determine if they were accountable. Standard operating procedures were reviewed to ensure that the documents are archived at the conclusion of the project.

Sample collection procedures were audited to determine if the samples are properly identified and if sample identification is maintained.

CEAT personnel observed the field activities to determine if the sample is maintained in the custody of the field collection team and if there are adequate security measures used in any areas identified as secure areas for sample storage.

The CEAT auditors recorded their observations on a checklist during the audit. At the conclusion of the audit, the audit teams held debriefings with the field teams. During the debriefings, the auditors discussed their findings and made recommendations for corrective action. Implementation of the corrective actions was discussed in these meetings and was verified at the conclusion of the Pilot Study during project file evidence audits conducted by the CEAT. Implementation of corrective action for the Soil Assessment for Indicator Chemicals Study will be reviewed when the complete project files are provided to the CEAT in the next quarter. Written reports of the field evidence audits were provided to the NEIC and the EPA project manager for review.

LABORATORY EVIDENCE AUDITS

CEAT personnel conducted evidence audits of all laboratory operations pertaining to chain-of-custody and document control procedures for the Pilot Study and the Soil Assessment for Indicator Chemicals Study. These audits included a minimum of three audits at each of the three laboratories participating in the Pilot Study, as well as at least two audits of each of the seven laboratories which participated in the Soil Assessment for Indicator Chemicals Study.

Procedures and documentation related to sample receiving, sample identification, sample security, sample storage, sample tracking, and project file organization and assembly were reviewed for conformance to Evidence Audit Requirements and the requirements stated in the LCHS Statement of Work. The CEAT auditors recorded their observations on a checklist during the audit.

The audits consisted of the following two components:

Procedural audit. The procedural audits consisted of a review and examination of actual and written standard operating procedures and accompanying documentation for the following operations: sample receiving, sample storage, sample tracking (from receipt to completion of analysis), and case file organization and assembly. The CEAT auditors followed the physical path of the samples and reviewed procedures and documents related to all activities associated with the samples. The security of each facility was reviewed.

Evidence audit. The evidence audits consisted of review and examination of project file documentation. The case file was reviewed to determine if the inventory is accurate and that all the documents related to sample receipt, sample transfer, sample preparation, and sample analysis are included in the case file.

At the conclusion of the audits, debriefings were held with the laboratory personnel. During these debriefings, the CEAT auditors presented the findings of the audit and recommendations for corrective action. Implementation of corrective action was discussed in the debriefings. Documents in the case files were reviewed at the conclusion of the Pilot Study to determine if corrective action had been completed. The auditors also reviewed corrective action on the items identified during previous laboratory evidence audits. Implementation of corrective action for the Soil Assessment for Indicator Chemicals Study will be reviewed when the complete project files are provided to the CEAT in the next quarter. Written reports of the laboratory evidence audits were provided to the NEIC and the EPA project manager for review.

ENVIRONMENTAL PROTECTION AGENCY
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DATE May 5, 1988

MEMORANDUM

To: Doug Garbarini
Emergency & Remedial Response Division, Region II

From: Robert H. Laidlaw
Project Officer

Subject: CH2M Hill Corrective Action Response to LCHS Field Evidence Audit Report

In reference to your request of March 30, 1988, NEIC tasked TechLaw to review whether CH2M Hill adequately responded to audit recommendations made during the October 1987 field sampling activity. Jeff Worthington has completed this review and his comments are attached. Chain-of-custody, document control, and evidence security procedures instituted by CH2M Hill and Cambridge Analytical Association meet evidence audit requirements.

Also attached is a summary of NEIC and TechLaw participation in the soil assessment program. We are pleased to provide this assistance. If you have any questions or comments please call me at FTS 776-5122.

Attachments

cc: Michael Travis, Contract Officer, PCMD (PM241-F)
Park Haney, Deputy Team Leader, CEAT
Jeffrey C. Worthington, CEAT

**CONTRACT
EVIDENCE
AUDIT
TEAM**

MEMO

TO: Rob Laidlaw, NEIC

FROM: Jeffrey C. Worthington, CEAT

DATE: April 12, 1988

SUBJECT: CH2M Hill Corrective Action Response to LCHS Field Evidence Audit Report

The Contract Evidence Audit Team (CEAT-TechLaw) has conducted a review of CH2M Hill's response to the CEAT recommendations in the January 11, 1988 LCHS Field Evidence Audit Report. The review was made in accordance with generally accepted evidence auditing standards.

Based on the corrective action described in CH2M Hill's response, the chain-of-custody, document control, and evidence security procedures followed by CH2M Hill and Cambridge Analytical Associates for the Love Canal Habitability Study meet or exceed Evidence Audit Requirements.

JCW:ad

cc: R. Park Haney, CEAT
Betty Malone, CEAT

IF: 111-068

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APPENDIX H

EMSL-LV/LEMSCo Involvement
Soil Assessment--Indicator Chemicals

Prepared by

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THE EMSL-LV INVOLVEMENT IN THE LOVE CANAL EMERGENCY DECLARATION AREA HABITABILITY STUDY SOIL ASSESSMENT -- INDICATOR CHEMICALS

by

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April 25, 1988

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THE EMSL-LV INVOLVEMENT IN THE
LOVE CANAL EDA HABITABILITY STUDY
SOIL ASSESSMENT -- INDICATOR CHEMICALS

1.0 INTRODUCTION

The U.S. EPA Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV) provided independent quality assurance support for the Love Canal Emergency Declaration Area (EDA) Habitability Study, Soil Assessment -- Indicator Chemicals (LCHSSA). The purpose of the support was to assist the U.S. EPA, Region 2 in obtaining defendable data of known and high quality for use in the decision making process. This report descibes the EMSL-LV participation in the study and the data validation procedures and results.

The data validation established that over seventy percent of the analytical field sample data was useable for the statistical analysis. This is a high percentage for a complex analytical method with strict quality assurance criteria.

1.1 Historical

The EMSL-LV involvement in the LCHSSA began in fiscal year (FY) 1986 when the USEPA Region 2 requested quality assurance support from the EPA Office of Research and Development who designated the EMSL-LV to provide this support. The LCHSSA is designed to provide information regarding the levels of chemical contamination in the area surrounding the Love Canal hazardous waste site and to assist the New York State Commissioner of Health in determining if the neighborhoods surrounding the site are habitable. The basis of the study is a comparison of the concentration of chemicals detected in the Love Canal neighborhoods and other similar residential areas in western New York State that are at least one-half mile from a chemical waste site. The comparison will be made using a selected set of eight indicator chemicals. One of the reasons this approach is being used is because there are no soil habitability limits available for the selected Love Canal Indicator Chemicals (LCIC). The LCIC selection process is presented in Love Canal Emergency Declaration Area / Proposed Habitability Criteria (NYSDOH and DHHS/CDC, December, 1986) and had been determined prior to the EMSL-LV involvement in the study.

The data acquired from previous studies indicated that the concentrations of LCIC expected to be present in the Love Canal area were significantly lower than existing analytical methods could detect. Since a statistical comparison of the areas requires "detects" to be effective, a new analytical method had to be developed. The decision was made to perform a pilot study to evaluate the new analytical methodology, the statistical approach, and to determine the number of samples required for the main study. A computerized sample tracking and data processing system was also developed and evaluated.

1.2 Pilot Study Involvement

The EMSL-LV and their contractors became involved in the LCHSSA at the analytical method development stage in November 1985, providing advice on the applicability of the proposed methods and the documentation and quality assurance measures which should be incorporated. The documentation and quality assurance requirements of the USEPA Contract Laboratory Program were used as guidelines for the Pilot Study and the LCHSSA.

The analytical method chosen was Selected Ion Monitoring (SIM) Gas Chromatography/Mass Spectrometry (GC/MS) with an alumina column cleanup of the extract prior to analysis. The data from method optimization work was reviewed and when performance appeared adequate, performance evaluation samples were prepared at the EMSL-LV for formal method validation and to evaluate the qualifications of the laboratories. The results of the analysis of these samples were reviewed and the analysis of a second set of performance evaluation samples was recommended. After the evaluation of these results, the decision was made to proceed with the Pilot Study.

During this same time period, onsite evaluations were performed at the participating laboratories to examine their capabilities for performing the analyses with the required levels of quality assurance and documentation. Additional onsite evaluations were performed during the Pilot Study to provide assurance that the analyses were being conducted according to the method and to provide assistance with unforseen method problems.

Several revisions of the Pilot Study Quality Assurance Project Plan (QAPP) were reviewed and the data review section, written at the EMSL-LV, was included in the QAPP.

An electronic bulletin board system was used to make Quality Assurance (QA) data generated by the laboratories available to the data reviewers, including EMSL-LV, soon after it was produced. As a consequence, the QA data could be evaluated, any out of control analyses identified, and corrective action taken promptly.

The data produced during the Pilot Study was reviewed to determine the quality of the data, the effectiveness of the required QA criteria and the performance of the method. Recommendations were made to Region 2 regarding changes to the method and QA procedures for incorporation into the plan for the main study.

Independently of the Pilot Study organized by Region 2, the New York State Department of Health (DOH) collected and analyzed samples from the Love Canal Emergency Declaration Area (EDA) and other areas within Niagara Falls, New York using a different method of analysis. In December 1986, the EMSL-LV contractor personnel visited the DOH to examine the data to determine its quality and its comparability with the Pilot Study data. The data were deemed to be of sufficient quality that the results were considered in the planning of the main study. The Niagara Falls areas sampled in the DOH study, which were not sampled during the Pilot Study, provided information on the distribution of trichlorobenzene and tetrachlorobenzene in Niagara Falls that was not available from the Pilot Study. This resulted in control areas within Niagara Falls being chosen for inclusion in the main study.

1.3 Method Modifications

The DOH requested that the detection limits of the method be lowered for the Habitability Study because of the large number of nondetected LCIC in the Pilot Study at the nominal detection limit of one microgram per kilogram (ug/kg). This required major modifications to the method cleanup and concentration procedures. The EMSL-LV participated in the method revision planning meetings and reviewed the method development data as it was produced. The modifications to the method resulted in lowering the detection limit to approximately 0.3 ug/kg for most of the LCIC.

1.4 Training Session

Prior to the start of the Habitability Study, the EMSL-LV and contractor personnel participated in a training session that was held for the laboratories selected to analyze the LCHSSA soil samples. The training session consisted of a demonstration of the extraction procedure and the laboratory personnel practicing the extraction procedure. The extracts were analyzed immediately to provide feedback as to the trainees' performances. Simultaneously, presentations were given to the laboratory project managers on the QA requirements and additional project administrative and logistical information.

1.5 PE Samples

Following the training session, performance evaluation (PE) samples were prepared and scored at the EMSL-LV as part of the method validation and laboratory qualification processes for the LCHSSA. The analytical standards to be used for the project were verified as to identity and concentration. Check standards were also prepared and distributed to the laboratories for comparison with the laboratory prepared working standards. The periodic analysis of the check standard gave additional evidence that the laboratories' calibrations were accurate.

1.6 BQC Samples

Three sets of "Blind Quality Control" (BQC) samples were also prepared at the EMSL-LV to be used for the study. The soil matrices were checked for contamination and then the samples were spiked with varying amounts of the LCIC which were unknown to the laboratories. One sample was required to be extracted in each batch of 10 or fewer samples and to be analyzed with that batch of samples. The results of these analyses were transmitted to the EMSL-LV for scoring within 24 to 48 hours to determine if reextractions were necessary.

1.7 Onsite Evaluations

The EMSL-LV and contractor personnel performed onsite evaluations of the field sampling teams, the sample preparation laboratory, and the analytical laboratories during the LCHSSA. The field sampling teams and preparation laboratory were observed at the beginning and the midpoint of the study. Each analytical laboratory was observed twice and laboratories 1, 3, and 4 were visited three times. A number of recommendations were made during these evaluations to improve procedures or to eliminate potential problems; however, no major problems were found.

1.8 Data Validation

The EMSL-LV reviewed the data and supporting documentation produced by the laboratories during the LCHSSA. Two series of flags were developed to characterize the quality of the data. The first was a set of detailed flags indicating QA deficiencies or other abnormalities of the data. The second was a set of summary flags which consolidated the detailed flags into a single qualifier for each analyte, indicating the usefulness of the data for the LCHSSA statistical analysis. See Tables 5a-b.

2.0 METHOD MODIFICATIONS

The EMSL-LV provided technical assistance in the method revision and validation process for the LCHSSA. This involved assisting in the implementation of recommendations from the Pilot Study and in the modification of the method to attain the lower detection limits requested by DOH. Attempts were also made to reduce the interlaboratory variability during the method revision process.

2.1 Recommendations

The EMSL-LV review of the Pilot Study data produced numerous recommendations to improve data quality for the LCHSSA. The details of this may be found in Appendix D of the Pilot Study Love Canal EDA Habitability Study Report; however, some of the more important recommendations follow. It was determined that blank interpretation must include interferences as well as LCIC contamination; the EMSL-LV proposed a set of blank interpretation rules that incorporated this concept, which were included in the LCHSSA QAPP. It was also decided that there must be a low concentration limit below which the laboratories do not expend great efforts to determine if the LCIC is present; this limit was set at 0.2 ug/kg. In addition, it was concluded that the raw data submitted by the laboratories must be presented in a manner that permits the reconstruction of the laboratories' results by an independent reviewer; the data package requirements were developed using the EPA CLP requirements as guidelines.

The Pilot Study included a volatiles method which was used to analyze for chlorobenzene and dichlorobenzene. The volatiles analysis had no chlorobenzene values over 1 ppb, dichlorobenzene was also analyzed in the semivolatile method, and found at higher concentrations in the semivolatile method. The volatiles method added significantly to the workload of the analytical laboratories without producing data of value. The decision was made to delete chlorobenzene as an LCIC and drop the volatile method from the LCHSSA.

The functional detection limits of the Pilot Study were approximately one part per billion (ppb) for most LCIC (i.e. below one ppb the interference structure of the chromatograms became so complex that data interpretation and review time became prohibitive). This resulted in the reporting of many samples with no LCIC detected. Because the statistical approach of the study requires "detects" to establish if a difference exists between the EDA and the control areas, the DOH requested that an attempt be made to lower the detection limit of the method for the LCHSSA.

2.2 Implementations

The EMSL-LV helped determine the most likely techniques to lower the detection limit while maintaining data quality, and then participated in the evaluation of the experimental results to determine if the method modifications met the goals. The method changes included changing the extract cleanup procedure by using silica gel instead of alumina and concentrating the extract to a smaller final volume. This also required changes in surrogate and internal standard concentrations, a reduction in the calibration range, and other minor changes. The results of the analyses using the modified method were reviewed and the EMSL-LV Performance Evaluation samples were used as the final step in the method validation process.

In order to reduce interlaboratory variability, several actions were taken. Critical pieces of glassware used in the extraction process were supplied by the project because some experimental evidence indicated a possible difference between brands of glassware. The solvents and other reagents used in the analyses were analyzed, and specific lots numbers with low background were supplied to the laboratories; this reduced the amount of blank interferences present in the LCHSSA.

The EMSL-LV reveiwed all method changes, QA requirements, reporting requirements, and QAPP revisions. The reviews were performed in an iterative manner and often occurred as participation in meetings, rather than formal review. This reduced the time required for revisions, thus shortening the time required for project completion.

2.3 Training Session

In an effort to further reduce interlaboratory variability and due to the complexity of the extraction procedure, a training session was held at Boston University for the extraction chemists and the laboratory project managers. The extraction chemists observed a demonstration of the extraction procedure, organized by project contractor staff, and then performed extractions while at the training session. The extracts prepared by each laboratory's representative were analyzed and the results were discussed. Simultaneously, project QA and administrative requirements were presented to the laboratory managers by project contractor and EMSL-LV personnel. Following the training session, the laboratories were sent practice samples by the prime contractor and then the first set of Performance Evaluation (PE) samples by EMSL-LV.

2.4 Standards Preparation and Evaluation

The standards used for the LCHSSA were prepared by the U.S. EPA Quality Assurance Materials Bank at Research Triangle Park, NC. The specific lot numbers of the standards provided to the laboratories were verified as to identity and concentration by the EMSL-LV laboratory. The individual LCIC, surrogate and internal standard solutions as well as the check standard solution were verified.

The 1-chloronaphthalene standard contained approximately twelve percent 2-chloronaphthalene. Efforts to obtain pure 1-chloronaphthalene commercially were unsuccessful. Pure 1-chloronaphthalene was synthesized at EMSL-LV but was not completed in time for use in the study. The 1-chloronaphthalene is used as part of the Performance Check/Continuing Calibration standard; the presence of the 2-chloronaphthalene impurity would tend to cause low bias of the 2-chloronaphthalene results in the field samples. The laboratories were told not to use a correction factor in the calculations as the impurity would not affect the goals of the study, which is a comparison approach, because all values would have the same bias.

3.0 PERFORMANCE EVALUATION AND BLIND QUALITY CONTROL SAMPLES

The EMSL-LV prepared Performance Evaluation (PE) samples and Blind Quality Control (BQC) samples for use in the LCHSSA. The PE samples were used to assist in the laboratory selection process and to demonstrate when the laboratories had acquired sufficient proficiency with the method to allow field sample analysis to proceed. They were also used for the final step in the method validation process and the results were used to establish limits for various quality assurance measures. The purpose of the BQC samples was to provide evidence in each extraction and analytical batch that the system was in control and that the laboratory was producing acceptable analytical results on a known sample.

3.1 PE and BQC Sample Preparation

The PE and BQC samples were prepared in the EMSL-LV laboratory using blank homogenized soil, similar to that found at Love Canal, and one batch of BQC samples was prepared with sand. Prior to use in the quality control sample, the homogenized soil matrix was extracted according to the method and evaluated for interferences and potential problems. Spiking solutions containing the LCIC were prepared and the concentrations were verified. The spiking solutions were spiked into the matrix and the jars were labeled using a coding system produced by a random number generator.

The first set of PE samples consisted of four samples whose concentrations were known and one sample whose concentration was unknown to the laboratories. The known samples were spiked at 0.1 ppb, 0.2 ppb, 0.5 ppb, and 2.0 ppb with all the LCIC. The unknown sample was spiked with 1.0 mL of a spiking solution containing the LCIC at varying concentrations. The results of these samples were also part of the method detection limit determination. A second set of PE samples was analyzed using samples which were prepared, in the manner described above, for use as the first batch of Blind Quality Control samples.

The BQC samples sent to the laboratories were from three different batches. The batch one BQC samples were prepared in the same soil used for the PE samples and were spiked at four different levels. The spiking solution prepared for the PE samples, containing the eight LCIC, was added to the samples at four different volumes, 0.5 mL, 1 mL, 1.5 mL, and 2 mL. The spike concentrations and results for these samples are provided in Tables 1a-d, spike levels A - D. The batch two BQC samples were composed of extra 0.2 ppb, 0.5 ppb and 2.0 ppb samples and the unknown PE sample from PE set 1. The spike concentrations and results for these samples are provided in Tables 1e-g, spike levels E - G. The laboratories required additional BQC samples and every effort was made to obtain more clean soil similar to that found at Love Canal. Three batches of soil were extracted and analyzed and none were acceptable for use in the study. Due the immediate need for more samples, it was necessary to use sand for the third batch of BQC samples. The batch three samples were prepared exactly as batch one, except using commercially available sand for the matrix. The spike concentrations and results for these samples are provided in Tables 1h-k, spike levels A - D. Each laboratory was sent 16-20 samples from batch one, 8-12 samples from batch two, and 10 samples from batch three.

3.2 PE Sample Evaluation

The results of the PE samples were evaluated at the EMSL-LV. The evaluation was performed by entering the analytical results into spreadsheets for statistical analysis and examining the accompanying raw data packages for analytical problems. A computer analysis, developed by EMSL-LV, was made on the analytical data to determine tentative acceptance windows for the results of the BQC samples. The statistical analysis on the first set of PE sample results produced windows which were excessively wide. This high variability among the laboratories' data indicated that the laboratories were not yet ready to analyze field samples. The analytical problems indicated by the data packages were examined and corrective actions recommended. These included laboratory specific actions and refinements to the analytical protocol. After the completion of these corrective actions, a second set of PE samples were analyzed by the laboratories. The results of this set of PE samples were acceptable, indicating that the laboratories chosen by the prime contractor were capable of performing the analysis. The results from the second set of PE samples were combined with the acceptable results from the first set to provide a larger database for establishing the control criteria for the BQC samples.

It was necessary to generate two sets of acceptance windows, for low and high concentration samples. The data from PE samples spiked with less than approximately 1 ppb of the LCIC were used to calculate the low concentration windows and the samples spiked with greater than approximately 1 ppb were used to calculate the high concentration windows. See Tables 6 and 7 for the data used to generate the windows and Tables 1a-k for the acceptance windows used for the individual spike levels.

The BQC samples were evaluated during real time quality assurance and again during data validation. See the individual sections of this report for details.

4.0 QUALITY ASSURANCE REQUIREMENTS

A number of Quality Assurance (QA) requirements were added to the QAPP at the request of the EMSL-LV in order to more closely monitor the quality of the data and to provide assurance that the analytical system was in control at all times. The items recommended and the rational are listed below.

4.1 Blind Quality Control (BQC) Samples

One BQC sample was required to be extracted with each batch of 10 or fewer field samples and the BQC sample associated with a particular extraction batch was required to be analyzed with all samples from that batch, except under certain specified conditions. This frequency requirement was added to provide evidence in each extraction and analytical batch that the system was in control. Strict reextraction/reanalysis requirements were also established for the BQC sample results.

4.2 EPA Check Standard

This solution, prepared by the U.S. EPA Quality Assurance Materials Bank at Research Triangle Park, NC and verified by EMSL-LV, contained the LCIC, surrogates and internal standards and was used to check that the standards used by the laboratories were accurate. The solution was required to be analyzed after each initial calibration, every two weeks and with batches of mixed rerun samples. If the calculated value of the check standard was not within 80-120 percent of the true value (70-120 percent for delta-BHC), corrective action was required and a check standard, which met criteria, had to be analyzed before field sample analysis could be resumed. This provided assurance that the laboratories' instruments were calibrated and that the seven laboratories obtained comparable results. In general, the laboratories had no problems meeting the check standard criteria.

4.3 Analytical Run

The concept of the analytical run was used for both extraction batches and instrument analysis batches. An extraction batch consisted of up to 10 field samples or matrix spike samples plus a BQC sample and a method/holding blank. An instrument analysis batch consisted of an initial combined system performance check/continuing calibration standard, a blank, a BQC sample or check standard, field samples and an ending system performance check standard. The idea was that the QC samples that were extracted with field samples would also be analyzed with them. This would provide evidence in all extraction and analysis batches that the analytical system was in control. The laboratories had the option of either a 12 hour or a 16 hour analysis sequence. The use of a 16 hour analytical sequence with a system performance check and calibration in the middle was allowed to make the analytical run compatable with the number of samples in an extraction batch. The 16 hour run enabled the laboratories to increase sample throughput with no decrease in the quality of the data, since a full extraction batch could not be analyzed in a single 12 hour shift but could be analyzed in 16 hours.

4.4 Laboratory Blanks

The laboratories that participated in the Pilot Study had varying amounts of the LCIC in their blanks due to the use of different brands or lots of reagents. Another problem in the Pilot Study was that the only criteria for an acceptable blank was the presence and concentration of LCIC contamination; interferences that were not positively identified as a LCIC were not considered. Several changes were implemented to decrease and control blank contamination because the LCHSSA required lower detection limits than the Pilot Study.

Prior to the Habitability Study, the reagents needed for the Soil Study were analyzed and specific lot numbers, that were acceptable according to the new blank requirements, were provided to all the laboratories. This proved to be an effective means of limiting LCIC contamination in the blanks. During the Habitability Study, the laboratories found similar levels of LCIC in their blanks. However, the presence of non-LCIC interferents posed a different problem. Each laboratory had somewhat different interferences, and when they were the same, the separation from the expected retention time of the LCIC tended to be different. The laboratories had varying degrees of problems with blanks. A common set of interferences was traced to detergent residues on the glassware used in sample extraction and cleanup. This was problem was resolved by a combination of modifying glassware cleaning procedures and adjusting chromatographic conditions.

A set of blank interpretation rules were developed by the EMSL-LV to allow the use of data which did not meet the exact definition of an acceptable blank. These rules allowed the use of data which contained interferences that did not impact the identification and quantitation of the LCIC. The rules facilitated the analysis of samples by the laboratories and provided significantly more usable data for the study. The blank rules and corresponding figures follow.

BLANK RULES

Rule 1: If more than one interference peak is present in the LCIC RRT window, the peak causing the most interference must be used for determining the acceptability of the blank. This may be the largest peak or the peak closest to the expected RRT, depending on the situation (see Figure 1).

Rule 2: Interference or LCIC peaks that are present in the blank but are not present in the samples (indicating a problem only with the blank) will not require reanalysis of the negative samples. (For the purposes of this section, a negative sample is defined as one that contains less than 0.2 ug/kg of LCIC response.)

Rule 3: If there is baseline resolution between an interference peak and the LCIC peak, then the blank is acceptable for that ion of that sample. If there is no signal above normal noise in the baseline at the expected RRT of the LCIC, then the blank is acceptable for that ion of that sample (see Figures 3a-b).

Rule 4a: If the blank contains more than 0.5 ug/kg (0.6 ug/kg for 1,2-dichlorobenzene) of a LCIC or the equivalent concentration of an interference at both the primary and secondary ions (the interference may be at different retention times) within the RRT window of an LCIC, all samples in the extraction batch containing a response greater than 0.2 ug/kg for that LCIC must be reextracted and reanalyzed (see Figure 4a).

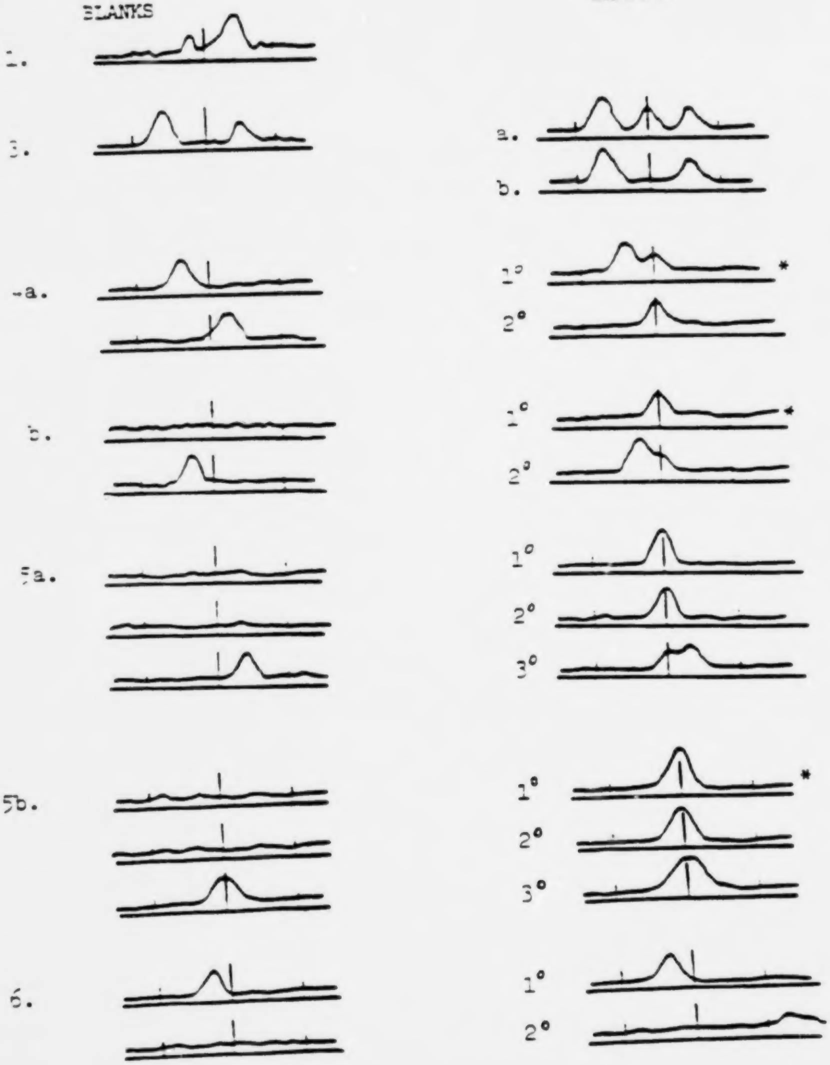
Rule 4b: If an interference peak is present within the LCIC RRT window at only the primary or secondary ion and the sample contains a peak greater than 0.2 ug/kg equivalent concentration at the appropriate RRT of the ion with no interference, the sample must be reextracted and reanalyzed (see Figure 4b).

NOTE: Rule 4 applies only if the conditions of Rule 3 are met.

Rule 5: If an interference peak that is present only at the tertiary ion in the blank is also present in the sample, and if the primary and secondary ions meet ion ratio criteria and at least a shoulder is observable on the tertiary ion interference peak at the LCIC RRT, the blank is acceptable for that ion of that sample. If a shoulder is not present or of the potential LCIC tertiary ion peak is totally obscured by the interference peak, the sample must be reextracted and reanalyzed (see Figure 5a-b).

Rule 6: If an interference peak is present within the LCIC RRT window at only the primary or secondary ion and the sample is a nondetect based on the ion without interference, reextraction and reanalysis are not required (see Figure 6).

BLANK RULE FIGURES



* Sample must be reextracted and reanalyzed

5.0 ONSITE EVALUATIONS

Onsite evaluations were performed at the laboratories participating in the LCHSSA to determine if the laboratories possessed the required facilities, personnel, and equipment, if the appropriate record keeping procedures were in place and being followed, and if the analytical protocol was being followed. Assistance was also provided to the laboratories in solving analytical problems and in interpreting the protocol. The onsite evaluation reports are available in the LCHSSA case file at the U.S. EPA, Region 2.

5.1 Analytical Laboratories

All of the laboratories were visited twice, and three of them three times, by teams consisting of one EMSL-LV EPA chemist and one EPA contractor chemist. Each team was accompanied by a representative of the prime contractor, and a representative of Techlaw, representing the National Enforcement Investigation Center (NEIC).

The first round of onsite evaluations was held at the beginning of the LCHSSA, in August 1987. The initial contact with the laboratories was at odd hours (late afternoon or evening) and without prior notice in order to observe the operations of the laboratory when they were not prepared for visitors. The laboratories had not started analyzing field samples at this time, so the onsite evaluations consisted of examining the facilities, procedures, and personnel qualifications. Each laboratory had appropriate facilities and instrumentation for participation in the study; however, they had procedural items to correct before sample analysis. Examples of procedural items that needed implementation or modification were: temperature logs, standards logbooks, standard operating procedures, and appropriate sample and standard storage procedures. Minor changes to clarify requirements were made to the protocol as a result of these onsite evaluations.

The second round of onsite evaluations was performed at the midpoint of the study, October 1987. Sample extraction and analysis procedures were observed, records for sample receipt, extraction, and analysis were checked, and problems the laboratory was having were discussed. Suggestions were made for minor improvements; however, no protocol modifications were made as a result of these visits. The Sample Preparation Laboratory was also visited during this round of onsite evaluations. The process of extruding the samples from the sampling tubes, homogenizing the samples and aliquoting the samples for shipment to the laboratories was observed. Minor recommendations were made to improve security and reduce the chances of sample cross-contamination.

The third set of onsite evaluations was performed near the end of the study, December 1987, when only three laboratories were still analyzing samples. Laboratories 3 and 4 were having analytical problems and laboratory 1 was preparing to analyze samples extracted by laboratory 4. The purpose of these onsite evaluations was to determine that the laboratories with problems were producing data of improved quality, to assist in problem solving, and to verify that laboratory 1 was still performing well since they would be receiving

The locations and dates of the onsite evaluations are listed below:

Laboratory Name and Location	Date
CH2M HILL, Montgomery, AL	August 26, 1987
Clayton Environmental Consultants, Novi, MI	August 26, 1987
NUS Laboratory, Pittsbugh, PA	August 26-27, 1987
Versar, Inc., Springfield, VA	August 27-28, 1987
Cambridge Analytical, Boston, MA	August 27, 1987
Aquatec, Inc., Burlington, VT	August 28, 1987
EMSI, Camarillo, CA	August 28, 1987
Versar, Inc., Springfield, VA	October 19, 1987
Clayton Environmental Consultants, Novi, MI	October 20, 1987
NUS Laboratory, Pittsburgh, PA	October 20, 1987
CH2M HILL, Montgomery, AL	October 21, 1987
Aquatec, Inc., Burlington, VT	October 22, 1987
Cambridge Analytical, Boston, MA	October 22, 1987
EMSI, Camarillo, CA	October 23, 1987
Versar, Inc., Springfield, VA	December 14, 1987
NUS Laboratory, Pittsburg, PA	December 16, 1987
Aquatec, Inc., Burlington, VT	December 18, 1987

5.2 Field Sampling Teams

Onsite evaluations were also performed by the EMSL-LV contractor field sampling audit team to observe the field sampling teams and the sample preparation laboratory. The sampling equipment, sample collection, sample preparation and sample shipping were evaluated. During the first onsite evaluation, the complete sampling process was reviewed and only minor procedural problems were observed, such as a sampler touched the exposed end of the liner with gloved hands, the sampler was rinsed before loose soil was brushed off, unlabeled wash bottles were used, etc. The second visit was to observe if the required QA procedures were still being followed. In general, the procedures presented in the soil sampling plan were being followed during the visits.

The locations and dates of the onsite evaluations are listed below:

Onsite Purpose and Location	Date
Love Canal Field Sampling, Niagra Falls, NY	October 14, 1987
Sample Preparation Laboratory, Boston, MA	October 15, 1987
Sample Preparation Laboratory, Boston, MA	October 21, 1987
Love Canal Field Sampling, Niagra Falls, NY	October 27, 1987

6.0 STATISTICAL SUPPORT

The EMSL-LV provided statistical support for the Love Canal Habitability Study. This support consisted of quality assurance and technical reviews. These efforts were performed by statisticians with substantial assistance from several chemists and technicians.

6.1 Quality Assurance

The EMSL-LV was responsible for establishing acceptance criteria for the performance evaluation materials for use in the LCHSSA. An acceptance window was determined for each of the seven PE samples based on observed laboratory analytical performance on these materials. The statistical procedures and software used were developed previously by the EMSL-LV for the Contract Laboratory Program. Basically, the procedure involves removing outliers by Grubb's test and then using the remaining data to estimate prediction intervals with the desired confidence level. These intervals were employed as acceptance criteria for the PE samples and the BQC samples.

6.2 Technical Reviews

The EMSL-LV statistical review function differed from the chemical review in that the EMSL-LV had little involvement in the planning and production stages of the statistical analyses. Only final reports were reviewed whereas, for the chemical analyses, the EMSL-LV was involved at all stages and provided iterative feedback as the project progressed. Each major report was reviewed and, at times, it was found appropriate to suggest changes or alternative approaches to problems.

The EMSL-LV will review the final statistical report, which is unavailable at this time, and submit a summary of the review comments will be submitted at a later date.

7.0 REAL TIME QUALITY CONTROL

The seven laboratories that participated in the LCHSSA were provided with a software package developed for the project called LabData. This software was used to track the samples in the laboratory, process the data from the mass spectrometer, and electronically transmit the results of the analyses to a secure bulletin board system. The data reviewers were provided with software to receive and evaluate the files sent by the laboratories. This system, Real Time Quality Control software (RTQC), made the QA data generated by the laboratories available to the data reviewers for examination on a daily basis so that problems could be identified and corrective action implemented promptly.

Most of the QA parameters required for the method were transmitted through the RTQC system. The parameters monitored through the system include: surrogate recovery, internal standard area and retention time differences, blank contamination, matrix spike/matrix spike duplicate recovery and relative percent difference, column performance check criteria, and sample status.

The EMSL-LV evaluated the data as an independent reviewer. The Bulletin Board was monitored at least daily and if laboratories had uploaded (sent) data files, the files were downloaded (received) and immediately logged into the Love Canal Computer Logbook. The files were evaluated for all the parameters listed above and any anomolies were recorded and reported to project management. However, the laboratories did not upload the results to the Bulletin Board daily as anticipated and some of the information proved more useful than others in evaluating the problems occuring in the laboratory. For example, if a surrogate recovery was out of criteria for a particular sample, it was impossible to tell if the sample was being reextracted until the results of the reextraction were posted. However, if the laboratory was only able to analyze a few samples per shift, a problem was indicated. The RTQC system did not meet all expectations but demonstrated the future potential for such a system. Another possible contribution of the RTQC system to the general high quality of the data was the psychological effect upon the laboratories of knowing their data was being scrutinized.

The software generated a special database containing the Blind QC sample results in a format to be merged into a program written at the EMSL-LV. The program calculated the percent recovery of each analyte in each sample, compared the recoveries to the appropriate acceptance windows, and flagged the analytes that did not meet criteria. A file was then generated that listed the analytes that were out of acceptance criteria for each sample, whether they were out high or low, and if the sample was acceptable or not. The results file was uploaded to the Bulletin Board, coded so that each laboratory could only able access their own results, with a turnaround time of 12 to 36 hours. Turnaround time was important because a failed Blind QC sample required reextraction of the entire associated batch of samples.

A number of problems occurred with the electronic transfer of the BQC sample data. For instance, one laboratory experienced problems with their data system and was unable to upload their results to the Bulletin Board for a few weeks. The EMSL-LV received the BQC sample results over the telephone and provided the results of the evaluation to the laboratory also by telephone. On other occassions, interference was found in the BQC samples that needed to be evaluated on an individual basis; for these cases, the raw data was sent to EMSL-LV for evaluation. Overall, the feedback system of the BQC sample results was very successful as the laboratories were provided with the results as promptly as their files were uploaded to the RTQC system.

8.0 DATA VALIDATION

The EMSL-LV was tasked to evaluate and qualify all data generated for the Love Canal Habitability Soil Study. This task included evaluating all the sample results, comparing the raw sample data to the data on the forms, and generating data qualifier and summary flags for every analyte in every sample. The Standard Operating Procedure (SOP) used to validate the data is provided at the end of this report.

8.1 Data Qualifiers

Individual qualifiers were developed to both denote anomolies in the data and identify data quality deficiencies. The qualifiers were applied only where necessary and were catagorized as follows: BQC samples, matrix spike/matrix spike duplicate samples, method/holding blanks, internal standards, holding times, surrogate recoveries, analytical sequence deviations, identification and quantitation, and miscellaneous. These flags were applied either to individual analytes or samples, depending on the impact of the data deficiency.

A system of summary data qualification flags was also developed to assist the statisticians in deciding which data to use for the statistical analysis. This system grouped the individual data flags into catagories based on the effect the flag had on the data. The summary flags are applied on an individual analyte basis to increase the amount of usable data for the statistical study. A description of each of the individual and summary data flags follows.

Individual Data Validation Qualifiers

G,U,B QUALIFIER	
	Blind Quality Control Samples (BQC)
U/B	E1 = If an analyte in a BQC sample is outside the acceptance criteria but the BQC sample is acceptable, that analyte in the BQC sample and the associated samples is flagged with "E1" (equivalent to the "E" flag in the SOW). This flag used in association with "Z8" is "U".
U	E2 = If a BQC sample is reinjected and an analyte(s) is outside the acceptance window, that analyte(s) in that reinjected BQC sample and the associated samples is flagged with "E2".
G/U	E3 = If an analyte in a BQC sample is reported as "ND" due to failed ion ratios and quantitation from the primary ion meets acceptance criteria, that analyte in the BQC sample and the associated samples is flagged with "E3".
U	E4 = The results of this BQC sample should be disregarded due to a possible problem in the preparation of the BQC sample rather than a laboratory problem; the BQC sample and the associated samples are flagged with "E4".
G/U	E5 = If an analyte in a BQC sample is reported as "ND" due to failed scan range and quantitation from the primary ion meets acceptance criteria, that analyte in the BQC sample and the associated samples is flagged with "E5".
B	E7 = If analytes in a BQC sample are outside the acceptance criteria and the BQC is not acceptable, those analytes in the BQC sample and the associated samples are flagged with "E7".
G/U	E8 = If an analyte in a BQC sample is reported as "ND" due to failed ion ratios as a result of interference at the primary ion and quantitation from the secondary ion meets acceptance criteria, that analyte in the BQC sample and the associated samples is flagged with "E8".

Matrix Spike/Matrix Spike Duplicate Samples (MS/MSD)

U M1 = If the percent recovery of an analyte in MS or MSD samples exceeds the advisory limit, that analyte (in the MS or MSD sample only) is flagged with "M1".

U M2 = If the percent recovery of an analyte in an MS or MSD sample is lower than the advisory limit, that analyte (in the MS or MSD sample only) is flagged with "M2".

U M3 = If the relative percent difference (RPD) of an analyte in a MS and MSD sample is outside the advisory limit, that analyte in both the MS and MSD samples is flagged with "M3".

B M4 = If the MS, MSD and native samples have surrogates that do not meet criteria, the MS and MSD samples only are flagged with "M4".

Internal Standards (IS)

U I2 = If an internal standard in a sample (except pyrene-d10, see I4) exceeds the area percent difference criteria, the analyte(s) quantitated using that internal standard is flagged with "I2".

B I3 = If an internal standard in a sample is out of the area percent difference criteria low, the analyte(s) quantitated using that internal standard is flagged with "I3".

G I4 = If pyrene-d10 exceeds the area percent difference criteria, the sample is flagged with "I4".

G I5 = If pyrene-d10 is out of the area percent difference criteria low, the sample is flagged with "I5".

Method Blank Samples

G B1 = If a peak within the relative retention time (RRT) window of an LCIC is greater than 0.5 ppb (equivalent concentration) and is NOT reported on the Form IV and has no impact on the associated samples, that analyte in the method blank is flagged with "B1".

G B2 = If a peak within the RRT window of an LCIC is greater than 0.5 ppb (equivalent concentration) using peak height or estimated peak height and is NOT reported on the Form IV and has no impact on the associated samples, that analyte in the method blank is flagged with "B2".

U/B B3 = If a peak within the RRT window of an LCIC is greater than 0.5 ppb (equivalent concentration), may or may not have been reported on the Form IV, and has an impact on the identification and/or quantitation of the analyte in the associated samples, that analyte in the affected samples is flagged with "B3".

G B4 = If a peak within the RRT window of an LCIC is greater than 0.5 ppb (equivalent concentration), may or may not have been reported on the Form IV, and has NO impact on the identification and/or quantitation of the analyte in the associated samples, the analyte in the blank only is flagged with "B4".

Identification and Quantitation

B Q1 = If a laboratory did not report the presence of an analyte but examination of the data shows the presence of a peak meeting all criteria at an equivalent concentration greater than 0.2 ppb, that analyte is flagged with "Q1".

B Q2 = If a laboratory reported the presence of an analyte but should have reported "ND" due to failed ion ratios, that analyte is flagged with "Q2".

U Q3 = If a laboratory reported the presence of an analyte but should have reported "ND" due to failed scan range, that analyte is flagged with "Q3".

G Q4 = If a spiked sample (i.e. BQC, MS/MSD, and EPA Check Std) has tertiary ion interference which is not found in the blank and interferes with identification of the analyte, the affected analyte is flagged with "Q4".

B Q5 = If samples exhibited apparent chromatographic reversal of B-BHC and G-BHC, the analytes are flagged with "Q5".

G Q6 = If an analyte does not exceed the calibration range as a wet weight, but does exceed the calibration range as a dry weight, the analyte is flagged with "Q6".

U Q7 = If an analyte(s) exceeds the calibration range, diluted or undiluted, wet weight and dry weight, the analyte(s) affected in the sample is flagged with "Q7".

U/G Q8 = If less than 20 ± 1 g (SOW required extraction weight) was extracted, the sample is flagged with "Q8".

U QA = If the B-BHC/G-BHC percent valley criteria for PC2 is not met, B-BHC and/or G-BHC in the positive samples in the associated shift are flagged with "QA".

Sample Qualifiers

B Z1 = If a surrogate(s) is outside acceptance criteria, the sample is flagged with "Z1".

U/G Z2 = If the corresponding BQC sample was not analyzed with samples from the associated extraction batch, the samples that are not analyzed in the same batch are flagged with "Z2". If the BQC sample was analyzed previously and was acceptable, and a BQC sample or an EMPC was analyzed in the analytical shift, there is no impact on the data quality (G).

G Z3 = If a native sample and MS/MSD samples were extracted on different dates, the MS/MSD samples are flagged with "Z3".

G Z4 = If a native sample and MS/MSD samples were extracted on the same date, but analyzed on different dates, the MS/MSD samples are flagged with "Z4".

U Z5 = If the BQC sample extracted with holding time (HT) samples is unacceptable, the BQC sample and all HT samples from that extraction batch are flagged with "Z5". Holding time samples can not be reextracted.

G Z6 = If the surrogate recovery is acceptable for the first injection of a sample, but unacceptable for the reinjection, the reinjected sample is flagged with "Z6".

U/G Z7 = If the associated method blank was not analyzed with samples from the same extraction batch, the associated samples not injected with the blank are flagged with "Z7". If the method blank was analyzed previously and was acceptable, and a method blank or an instrument blank was analyzed in the analytical shift, there is no impact on the data quality (G).

G Z8 = If the BQC sample extracted and analyzed with the samples is a very low level spike (0.2 ppb) with advisory limits, the samples and BQC sample are flagged with "Z8".

B Z9 = If the BQC sample extracted and analyzed with the sample is unacceptable, the samples and the BQC sample are flagged with "Z9".

G ZA = If the BQC sample extracted and analyzed with the sample was a sand matrix, the samples and the BQC sample are flagged with "ZA".

G ZB = If the method blank from the appropriate extraction batch was not reinjected with a reinjected sample, the reinjected sample is flagged with "ZB".

G ZC = If the BQC sample from the appropriate extraction batch was not reinjected with a reinjected sample, the reinjected sample is flagged with "ZC".

G ZD = If the ion ratio of pyrene-d10 is outside the criteria for PC2, the samples in the shift are flagged with "ZD".

G ZE = If the lab analyzed the method blank associated with rerun samples and an EMPC instead of the associated BQC sample, the samples are flagged with "ZE".

G ZF = If the native and/or MS/MSD samples were extracted and analyzed on different dates, the MS and MSD samples are flagged with "ZF".

G ZG = If a BQC sample, previously analyzed and acceptable, went dry and could not be reinjected with reinjected samples, but an EMPC was analyzed with the reinjected samples, the reinjected samples are flagged with "ZG".

G ZH = If the wrong peak was evaluated for pyrene-d10 at m/z 213, the affected sample is flagged with "ZH".

G ZI = If the wrong peak was evaluated for pyrene-d10 at m/z 213 in the PC2, the samples in the analytical shift are flagged with "ZI".

U ZJ = If the concentrations on a Form I are wet weight and not dry weight because percent moisture is not indicated on the form, the sample is flagged with "ZJ".

Holding Time Qualifiers

U H1 = Samples that exceed the analysis holding time, 50 days from verified time of sample receipt, are flagged with "H1".

U H2 = Samples that exceed the extraction holding time, 30 days from verified time of sample receipt, are flagged with "H2".

U H3 = Samples that exceed the extraction and/or analysis holding times due to reruns requested by EMSL-LV after the data package was submitted are flagged with "H3".

U H4 = Samples that exceed both the extraction and analysis holding times are flagged with "H4".

Resubmission Qualifiers

G K2 = If a small discrepancy exists between the concentrations on the Form I and the calculated concentrations from the quantitation report which was not resolved by resubmissions, the sample is flagged with "K2".

Summary Qualifiers

G This flag is used on analytes which have either no data quality defects or have technical violations of the QAPP which have no effect on data quality. Data with this flag may also have informational flags.

U This flag is used on analytes which have significant data quality defects but only low probability of this having an effect on the quality of the data. This includes holding time violations and exceeding the calibration range etc. Data with this qualifier is usable for some purposes and most of the defects which make up this catagory would result in reported values which are lower than expected. This data should only be used by persons knowledgeable in the effects a particular deficiency would have on the data.

B This flag is used on analytes which have data quality defects that may, but do not necessarily have an effect on the data. Examples of this are BQC samples out of criteria, surrogates out of criteria, method/holding blanks out of criteria, etc. Data with this flag should be used only with extreme care and with full knowledge of the limitations of the data quality and the consequences of using flawed data.

These flags are applied to the data to reflect compliance with the QA criteria in the QAPP and Good Laboratory Practice. They do not indicate compliance with nontechnical requirements of the QAPP and are not intended to do so.

8.2 Count of Data Validation Qualifiers

The Form I's were marked with all the individual and summary data qualifiers and provided to software contractor for entry into a database. A summary count of some selected flags used to qualify the data are listed in Tables 5a-b, Summary of Data Validation Qualifiers from Form I Database. The counts in both tables are by analyte and not by sample. The counts for the individual qualifiers should not total the counts of the summary qualifiers because more than one individual qualifier may apply to the same data point in the database.

The data presented in Table 5a gives the number and percentage of each analyte by laboratory that were assigned each of the G, U, and B summary qualifiers. The range of "G" analyses between laboratories, 54.9 to 92.2 percent, is significant. Both laboratories 3 and 8 had many samples which exceeded holding times due to reextraction and reanalysis (see Table 5b). This is the primary cause of the wide range in the percentage of "G" data. The total "G" data, 72.4 %, should be considered an achievement for a method of this complexity and the level of review to which the data was subjected.

The data presented in Table 5b contains the distribution of a selection of the individual data qualifiers by laboratory. The flags chosen are some of those which apply to the field samples and have an impact on the data. The definition of the flags are given above. The table shows that the laboratories had different QA defects in their data which indicates that the problems are not method deficiencies.

8.3 Blind QC Sample Results

The BQC sample results, monitored during the study using the RTQC software, were also evaluated during the Data Validation process. The BQC sample Form I and RTQC results were compared to the raw data of the BQC sample.

The results of the BQC samples were evaluated using the criteria outlined in the QAPP, Exhibit A2-24, Section 3.13.2. If two or more LCICs were out of the acceptance criteria, the BQC sample was unacceptable. The BQC sample was considered acceptable if fewer than two analytes were out of criteria, unless the same analyte was out of criteria for three out of five consecutive BQC samples. If this was the case, the three BQC samples with the particular LCIC out of limits were unacceptable and the samples associated with the unacceptable BQC samples were required to be reextracted. The BQC samples were compared to the appropriate low or high concentration acceptance windows as explained in the PE Sample section of this report and as provided on Tables 1a-k.

The results of the BQC samples were routinely uploaded by the laboratories to the Bulletin Board at the beginning of the study; however, towards the end of the study, a number of laboratories did not send the results for evaluation or did not check the Bulletin Board for the results of the evaluation by EMSL-LV. As a result, during the validation process, a few samples were determined to be unacceptable, which invalidated all the samples associated with those BQC samples.

A review of the BQC sample raw data revealed that in most cases where a "ND" (nondetect) was reported on the Form I, the analyte either did not meet ion ratio, scan range or RRT criteria, but the quantitation from the primary ion was within the acceptance criteria. The BQC sample data entered into the Form I database was condensed into summary tables by matrix, spike level, and laboratory. When an analyte was reported as "ND" on the Form I because it did not meet all of the identification criteria, the concentration for the summary tables was calculated using the primary ion. If the Form I indicated the need to use peak height or secondary ion quantitation, the concentration reported was calculated accordingly. A number of other anomolies with the data were observed and are indicated as appropriate in Table 4, Summary of Flags Used to Qualify the BQC Sample Data.

Tables 1 - 3 present the data from the BQC samples which were analyzed with each batch of samples. Tables 1a-k summarize the percent recovery and percent relative standard deviation (% RSD) of the individual spiking levels by laboratory and matrix. These tables demonstrate that within the concentration ranges used, there was no apparent concentration related recovery bias in the method. The 0.2 ug/kg spike level (spike level E) has high recoveries for 1,2-dichlorobenzene and 1,2,4-trichlorobenzene due to traces of these compounds in the method blanks. Tables 2a-b present the mean percent recovery and mean % RSD averaging all spike levels by laboratory and matrix. These tables display any interlaboratory bias for each LCIC. Tables 3a-b are summaries of the overall mean percent recovery and mean % RSD for the study for each LCIC by matrix. These tables demonstrate the difference in analytical behavior among the LCIC.

Two matrices were used for the BQC samples as described in the Sample Preparation Section. The results of the two matrices are reported separately to illustrate the performance of the method on different matrices. In general, the recoveries and the % RSDs of the LCIC from sand samples was lower than from the soil samples, except for laboratory 7. The lower % RSDs for the sand samples was anticipated whereas the lower recoveries were not. Neither of these differences has an impact on the utility of the BQC samples as a QA measure for determining that the laboratory's analytical system was in control. The use of BQC samples was a valuable QA measure since many of the out of criteria samples exhibited deficiencies in other QA criteria, such as surrogate recoveries. In general, the laboratories performed well on the BQC samples; approximately 90 percent of the first analyses were acceptable, not including the results from laboratory 4.

8.4 Data Validation Comments

The EMSL-LV estimated that the validation of the data for the LCHSSA would take ten weeks if the data were received in three equal portions, on schedule. The data packages were not received as scheduled and the validation required approximately twelve weeks, from mid-November, 1987 to mid-February, 1988. A number of other problems occurred during the validation process which are discussed below.

The Data Validation software (DVS), developed by software contractor, was used as an organization and documentation tool during the validation process. Due to schedule constraints, there was inadequate time to thoroughly debug the software and properly train the necessary personnel in its use. As a result, a number of problems existed in the software that were identified when it was already in use; the problems were corrected soon after they were identified. The reports and checklists generated by the software were used, but the data evaluation was not done at the keyboard as anticipated. A new version of the software was provided to EMSL-LV after data validation was complete. The data evaluation and comments were entered into the computer retroactively so that the information would be available in the LCHSSA database for future reference.

The LabData Software provided to the laboratories generated the Data Validation diskettes when the final data package forms were produced. Many of the laboratories did not follow the directions provided with LabData and in Project memos which caused problems with the Data Validation software. For example, duplicate Lab Login ID's were left in the databases. For a 16 hour analytical run, the PC2 of the first shift was supposed to be named "PCMID"; this convention was not followed. Unacceptable analyses were not removed from the final database. All these anomolies caused the DVS not to function properly.

The conventions for the laboratories to qualify their data were not sufficiently clear in the SOW. For example, every laboratory had low levels (less than 0.5 ppb and 0.6 ppb for 1,2-dichlorbenzene) of some of the LCIC in the method/holding blanks. Laboratory 1 qualified all samples associated with a blank that had LCICs less than the 0.5/0.6 ppb with a "B" qualifier. No other laboratory did this. It is not clear from reading the SOW whether the analytes should or should not be qualified with the "B". This inconsistency still exists in the Form I database. In addition, the laboratories did not use the "E" qualifier as defined in the QAPP, p. A4-13, Section 2.4.4.

There is a field on the Form I for sample screening information; the options to complete the field are MS or ECD. If the sample was screened, that field must be completed. Only one laboratory that participated in the study actually completed the field. The only way for the data evaluator to determine if a sample was screened was to search through the instrument run logs and the screening raw data. There were too many instances where the information was not provided on the Form I for the EMSL-LV to request resubmissions to correct this deficiency.

The date of receipt, date of extraction, percent moisture, and weight extracted needed for the Data Validation software were provided from the same database as for the Sample Extraction Summary Report, Form IX. The information entered into the database for the Form IX was not reviewed thoroughly by some of the laboratories and, as a result, the information on the forms and DVS did not always match the information on the handwritten logbooks. This caused problems during the validation process. In addition, a number of laboratories had difficulty generating the Matrix Spike Form (Form III) but the required resubmissions corrected the problems.

8.5 Laboratory Specific Comments

The following is a detailed discussion of the data from the individual laboratories, including problems encountered and comments on the overall data quality.

Laboratory 1 produced data of excellent quality. The data packages were received on schedule. Very few resubmissions were needed as a result of the thorough review the laboratory performed on their own data. This laboratory was asked to participate in the holding time study and to analyze the samples extracted by laboratory 4. The Count of Individual Qualifiers from the Form I Database, Table 5b, indicates a significant number of "E1" qualifiers for this laboratory. The explanation for this is twofold. One, a few sand BQC samples that were extracted in batches with Holding Time samples only, failed criteria and could not be reextracted. This also accounts for the high % RSDs for the sand samples, Table 2b. Two, the counts for laboratory 1 include the counts for laboratory 4, which had trouble with the BQC samples. Despite this aspect of the data, the overall work performed by laboratory 1 was outstanding.

Laboratory 2 had a number of specific problems. The sensitivity of their instrument was very low, particularly for the BHCs. As a result, many manual integrations were necessary. Numerous resubmissions were requested for reevaluation of BHC integrations in the method/holding blanks. In addition, the data system did not always choose the proper peak for pyrene-d10 at m/z 213, which was not caught in-house. The SICP and quantitation reports were resubmitted when this problem occured. Approximately half of the Form III's were generated incorrectly due to a problem with LabData and needed resubmission. Towards the end of the study, laboratory 2 did not retrieve the results of the BQC sample evaluations from the Bulletin Board. A number of the BQC samples were deemed unacceptable during RTQC and data validation, which invalidated data from numerous samples. This problem is reflected in the number of "E7" flags for laboratory 2 in Table 5b. The requested resubmissions were not received in a timely manner which delayed validation of the data.

Laboratory 3 had difficulty meeting the BQC sample acceptance criteria at the beginning of the study and three of the early extracted batches required reextraction. As a result, the first data package was very small and many of the samples that required reextraction exceeded holding times. This is reflected in the number of samples for this laboratory with "H" flags. This laboratory did not thoroughly review their data in-house, and numerous resubmissions were needed. At the beginning of the study, peaks that met criteria were not reported on the Form I's; the laboratory staff was informed of this problem and corrected the problem for the later data packages. The data packages were put together carelessly and often had items missing. The items listed indicate a problem with organization and not technical quality. The overall quality of the data was acceptable and all the requested resubmissions were received promptly.

Laboratory 4 extracted their samples but were unable to perform the analysis. The decision was made to send the extracts to laboratory 1 to be analyzed. Many of the BQC samples did not meet acceptance criteria so the remaining samples from those extraction batches were never analyzed. The cause of the problems is unclear.

Laboratory 5 did not complete the qualification process.

Laboratory 6 did not submit the data packages on schedule. Upon review of the first data package, it was discovered that the proper analytical sequence was not followed for some shifts; the BQC samples associated with the field samples were not analyzed in the same shifts. The laboratory was required to reanalyze the approxiately 50 affected samples. The reanalyzed samples exceeded the analysis holding times which accounts for the number of samples with "H" qualifiers. The SICPs for 2-chloronaphthalene in the first data package were not displayed on the appropriate scale and were corrected through resubmissions. Some of the requested resubmissions were not submitted in a timely manner which delayed validation of the data. The majority of problems listed indicate organizational problems and not technical problems. Overall, the data was of acceptable quality.

Laboratory 7 had a problem with their data system and LabData Software. As a result, the data packages were received late and in one shipment, not three. The data system was set up so that many manual integrations were necessary, which increased the time for data validation. The data package was missing a few quantitation reports and was not put together properly, but very few resubmissions were needed. This laboratory had a problem with internal standards out high, even after reinjection, as is reflected in the number of "I2" and "I4" flags. The resubmissions that were requested were received promptly. Overall, the data was of acceptable quality as reflected in the data qualifier flags.

Laboratory 8 submitted the data packages late. A number of unnecessary reextractions were performed because a surrogate or an internal standard was within, but close to the QA criteria limit. This caused confusion during data validation. For example, the BQC sample was deemed acceptable by EMSL-LV but the data was not submitted because the surrogate recovery was low, yet acceptable. To the data evaluator, it appeared that the associated BQC sample was not analyzed with the samples. Resubmissions for this type of data were requested. Resubmissions were necessary for a number of Form III's and Form I's where hand-written corrections were made. The number of "H" qualifiers indicates that many reanalyzed samples did not meet the holding time criteria. The requested resubmissions were not submitted in a timely manner, however, most of the deficiencies were corrected. Overall, the data was of acceptable quality.

8.6 QA Criteria Summary

The following is a summary of the general performance of the QA criteria.

- Initial Calibration: All the initial calibrations reported met the QA criteria.

- Performance Check: One PC2 failed percent valley criteria and the remainder were acceptable.
- Continuing Calibration: All the continuing calibrations reported met QA criteria.
- EPA Check Standard: All reported EPA check standard analyses met the QA criteria.
- Internal Standard Area Difference: This criteria was not met numerous times as indicated by the number of "I" qualifiers. The failure to meet the criteria resulted in many reanalyses.
- Internal Standard Retention Time Differences: This criteria was generally met.
- Surrogate Recovery: The number of reported surrogates recoveries outside the QA criteria was low; however, a significant number of samples were reextracted when the surrogate recovery did not meet criteria.
- Matrix Spike/Matrix Spike Duplicate Samples (advisory): The advisory recovery and RPD criteria were not consistently met. The problems were not specific to any particular LCIC and time constraints have not permitted a detailed examination of this data by the EMSL-LV at this time.
- Method/Holding Blanks: The method/holding blanks generally met the QA criteria after the detergent problem was solved. See Section 4.4 for a detailed discussion of the blanks.

9.0 SUMMARY

The results of the data validation indicated that the QA measures incorporated into the QAPP were effective in the production of data of high and known quality. The combination of project provided reagents and glassware, analyst training, rigorous QA requirements and monitoring of the laboratories during the study was used to reduce interlaboratory variation and to ensure the quality of the data.

The method modifications introduced to lower the detection limit and reduce interferences succeeded in lowering the effective detection limit from approximately one ppb to approximately 0.3 ppb. This resulted in many more samples with detected LCIC than in the Pilot Study.

The training of the extraction analysts in the use of the method by the chemists who developed it was instrumental in reducing the time required for the laboratories to become competent in using the new method. This, in combination with the analysis of PE samples, resulted in the laboratories having fewer startup problems than anticipated.

The RTQC system performed adequately. The schedule demands of the project required the system to be used before the software was completely ready. This resulted in some delays in uploading data for review. The system was of great value in the transmisson of the Blind Quality Control sample results to the EMSL-LV for scoring.

The method/holding blank interpretation rules were successful in permitting the use of large amounts of data which would have been classified as having blank interference if only the usual blank definition was used.

The data validation proceeded nearly as planned; some schedule slippage was experienced due to delays in receipt of materials from the laboratories. The detailed examination of the data showed that when data defects were present the quality assurance measures incorporated in the protocol indicated a problem. This indicates that no additional quality assurance measures were needed.

The data produced by the laboratories is of known quality with a large proportion of it suitable for statistical use in the LCHSSA. The laboratories in general performed very well on a tight schedule with a heavy sample load. The detailed comparison of the data produced to the project Data Quality Objectives is presented elsewhere in the LCHSSA project report.

SUMMARY TABLE FOR LOVE CANAL SOIL BQC SAMPLES BY SPIKE LEVEL

TABLE 1a

SPIKE LEVEL A

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WINDOW	LAB 1			LAB 2			LAB 3			LAB 4			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	0.60	56.4 - 170.5	5	109.7	4.3	6	89.2	1.3	3	108.9	4.4	2	88.3	0.0	3	126.1	15.2	3	92.2	2.6	2	130.8	1.6
1,2,4-TRICHLOROBENZENE	0.45	53.9 - 162.2	5	87.6	0.6	6	85.9	1.0	3	134.1	3.9	2	81.1	0.4	3	113.3	2.1	3	82.2	1.1	2	101.1	0.9
1,2,3,4-TETRACHLOROBENZENE	0.50	50.7 - 107.7	5	65.6	2.7	6	70.3	4.0	3	93.3	2.7	2	52.0	1.4	3	92.0	2.0	3	64.0	0.8	2	83.0	3.8
2-CHLORONAPHTHALENE	0.40	31.7 - 98.5	5	58.0	1.2	6	60.0	1.4	3	55.8	0.4	2	56.2	1.5	3	67.5	4.1	3	46.7	1.0	2	70.0	1.6
ALPHA-BHC	0.70	40.0 - 125.[illegible]	5	69.7	4.6	6	60.2	9.9	3	71.9	8.4	2	69.3	7.9	3	77.6	4.6	3	57.1	3.2	2	69.3	3.6
DELTA-BHC	0.60	28.6 - 184.5	5	54.0	5.9	6	50.8	6.5	3	77.2	8.5	2	41.7	10.2	3	78.9	7.8	3	60.6	3.2	2	71.7	7.1
BETA-BHC	0.75	11.2 - 168.9	5	62.7	5.2	6	56.7	13.8	3	111.1	42.1	2	54.0	12.8	3	80.4	25.0	3	81.8	9.0	2	79.3	2.0
GAMMA-BHC	0.65	35.1 - 120.0	5	67.4	6.4	6	57.9	8.6	3	80.5	16.0	2	53.8	5.1	3	79.0	6.2	3	63.6	5.8	2	75.4	4.9
1,4-DIBROMOBENZENE	-	51.0 - 104.0	5	71.2	2.4	6	85.4	13.6	3	74.2	0.9	2	71.8	1.1	3	82.0	7.4	3	73.0	13.9	2	87.8	6.7
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	5	78.1	8.3	6	97.3	15.1	3	97.0	12.4	2	77.8	12.9	3	90.6	15.0	3	92.8	36.6	2	103.5	0.7
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	5	64.9	6.0	6	89.0	17.5	3	86.2	7.2	2	71.8	1.4	3	80.9	5.8	3	78.7	23.1	2	88.2	1.1

TABLE 1b

SPIKE LEVEL B

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WINDOW	LAB 1			LAB 2			LAB 3			LAB 4			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	1.20	42.3 - 112.2	8	72.7	14.0	16	77.8	17.1	8	79.1	24.4	1	54.2	-	7	88.5	14.1	4	70.0	11.3	4	86.5	41.9
1,2,4-TRICHLOROBENZENE	0.90	45.6 - 109.3	8	68.3	6.5	16	74.3	10.9	8	92.4	9.2	1	56.7	-	7	86.7	7.4	4	70.3	13.6	4	75.8	19.5
1,2,3,4-TETRACHLOROBENZENE	1.00	44.3 - 93.3	8	60.5	10.6	16	61.1	12.0	8	81.5	8.8	1	52.0	-	7	81.3	9.9	4	67.5	13.6	4	67.0	23.0
2-CHLORONAPHTHALENE	0.80	30.6 - 74.8	8	49.2	8.9	16	47.1	11.8	8	46.1	9.0	1	53.7	-	7	57.1	7.9	4	47.5	14.2	4	38.4	30.3
ALPHA-BHC	1.40	37.1 - 116.2	8	57.9	27.9	16	61.7	33.4	8	74.5	15.1	1	47.9	-	7	76.6	21.4	4	64.5	29.2	4	73.8	51.1
DELTA-BHC	1.20	17.8 - 148.2	8	46.6	20.5	16	51.6	40.0	8	86.5	61.8	1	30.8	-	7	75.0	21.8	4	55.4	28.8	4	67.9	26.1
BETA-BHC	1.50	44.6 - 128.0	8	50.7	22.6	16	57.2	50.4	8	73.9	29.7	1	42.7	-	7	89.4	123.0	4	70.2	40.4	4	76.8	58.9
GAMMA-BHC	1.30	42.4 - 122.6	8	53.3	17.0	16	60.3	30.2	8	78.6	21.0	1	41.5	-	7	77.1	20.8	4	66.9	32.8	4	73.7	33.6
1,4-DIBROMOBENZENE	-	51.0 - 104.0	8	71.2	3.9	16	88.1	7.0	8	68.3	7.2	1	86.5	-	7	74.5	9.0	4	89.2	6.9	4	79.7	5.3
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	8	75.0	8.8	16	104.2	11.6	8	96.0	8.7	1	92.0	-	7	92.2	14.8	4	111.3	14.7	4	89.0	21.3
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	8	68.1	10.8	16	92.4	9.2	8	137.6	93.0	1	72.7	-	7	79.1	6.0	4	95.9	7.0	4	90.2	19.5

SUMMARY TABLE FOR LOVE CANAL SOIL BQC SAMPLES BY SPIKE LEVEL

TABLE 1c

SPIKE LEVEL C

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WIND	LAB 1			LAB 2			LAB 3			LAB 4			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	1.80	42.3 - 112.2	2	71.1	3.6	5	67.1	10.3	2	77.8	9.8	1	53.3	-	2	53.6	7.1	3	67.6	15.1	2	78.3	6.5
1,2,4-TRICHLOROBENZENE	1.35	45.6 - 109.3	2	68.1	5.6	5	63.4	8.3	2	95.6	6.0	1	60.7	-	2	64.4	8.9	3	72.6	22.6	2	77.4	1.2
1,2,3,4-TETRACHLOROBENZENE	1.50	44.3 - 93.3	2	64.3	1.6	5	65.9	34.2	2	88.0	12.1	1	50.0	-	2	67.7	14.1	3	66.7	27.4	2	64.7	6.6
2-CHLORONAPHTHALENE	1.20	30.6 - 74.8	2	48.3	7.0	5	47.2	14.2	2	34.2	0.0	1	46.7	-	2	46.3	12.8	3	35.8	15.3	2	24.6	107.0
ALPHA-BHC	2.10	37.1 - 116.2	2	63.1	40.0	5	58.4	28.0	2	68.3	45.6	1	49.5	-	2	72.9	8.2	3	65.1	96.5	2	85.0	54.2
DELTA-BHC	1.80	17.8 - 148.2	2	61.4	51.8	5	45.8	46.0	2	59.4	21.4	1	42.2	-	2	61.1	141.6	3	61.3	61.6	2	81.4	120.4
BETA-BHC	2.25	44.6 - 128.0	2	59.3	2.7	5	59.6	88.0	2	69.3	73.4	1	45.8	-	2	74.7	8.5	3	69.6	84.0	2	80.7	151.9
GAMMA-BHC	1.95	42.4 - 122.6	2	63.3	45.7	5	58.6	33.4	2	68.7	68.2	1	47.2	-	2	75.9	32.7	3	65.0	38.6	2	84.4	89.9
1,4-DIBROMOBENZENE	-	51.0 - 104.0	2	73.7	2.8	5	87.3	12.2	2	73.3	4.5	1	72.6	-	2	67.7	3.0	3	88.1	15.3	2	83.0	15.6
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	2	82.9	10.9	5	90.3	5.7	2	91.8	9.5	1	75.8	-	2	85.0	8.2	3	102.0	10.5	2	97.5	3.5
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	2	68.9	8.6	5	84.3	8.8	2	104.0	11.3	1	78.7	-	2	77.9	23.4	3	76.9	17.4	2	94.4	23.5

TABLE 1d

SPIKE LEVEL D

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WINDOW	LAB 1			LAB 2			LAB 3			LAB 4			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	2.40	42.3 - 112.2	5	67.8	87.4	7	68.0	70.7	6	60.3	80.6	-	-	-	6	67.6	104.4	3	66.5	83.5	4	76.1	92.6
1,2,4-TRICHLOROBENZENE	1.80	45.6 - 109.3	5	68.7	51.5	7	70.4	56.8	6	73.3	56.9	-	-	-	6	79.3	30.4	3	67.6	12.6	4	77.9	23.2
1,2,3,4-TETRACHLOROBENZENE	2.00	44.3 - 93.3	5	64.1	68.2	7	62.6	63.8	6	70.3	46.3	-	-	-	6	80.3	41.9	3	75.8	66.0	4	67.3	39.3
2-CHLORONAPHTHALENE	1.60	30.6 - 74.8	5	52.2	41.2	7	49.6	21.4	6	37.4	110.3	-	-	-	6	42.6	106.4	3	60.8	50.5	4	45.9	34.9
ALPHA-BHC	2.80	37.1 - 116.2	5	61.4	92.8	7	59.8	93.8	6	75.5	140.6	-	-	-	6	85.4	144.0	3	65.2	249.2	4	83.7	118.6
DELTA-BHC	2.40	17.8 - 148.2	5	56.7	42.7	7	46.3	96.7	6	54.4	134.2	-	-	-	6	86.0	135.3	3	62.9	150.1	4	69.8	90.7
BETA-BHC	3.00	44.6 - 128.0	5	61.6	25.9	7	49.0	174.0	6	71.0	158.3	-	-	-	6	102.0	424.7	3	72.7	224.8	4	73.2	135.0
GAMMA-BHC	2.60	42.4 - 122.6	5	60.1	85.9	7	56.9	102.3	6	77.3	154.1	-	-	-	6	94.8	114.5	3	64.9	182.8	4	83.8	82.2
1,4-DIBROMOBENZENE	-	51.0 - 104.0	5	71.7	8.2	7	81.7	9.9	6	62.1	6.0	-	-	-	6	80.4	6.2	3	83.7	9.4	4	84.7	7.1
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	5	70.4	12.2	7	89.1	13.3	6	91.6	17.5	-	-	-	6	94.8	11.7	3	103.3	40.6	4	100.4	3.5
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	5	73.4	9.0	7	69.6	6.9	6	92.6	14.5	-	-	-	6	99.8	43.6	3	87.3	20.0	4	91.5	12.4

SUMMARY TABLE FOR LOVE CANAL SOIL BQC SAMPLES BY SPIKE LEVEL

TABLE 1e

SPIKE LEVEL E

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WINDOW	LAB 1			LAB 2			LAB 3			LAB 4			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	0.20	56.4 - 170.5	3	200.0	0.6	2	210.0	0.5	-	-	-	-	-	-	1	165.0	-	2	140.0	0.6	1	380.0	-
1,2,4-TRICHLOROBENZENE	0.20	53.9 - 162.2	3	106.7	0.5	2	107.5	0.1	-	-	-	-	-	-	1	110.0	-	2	107.5	0.4	1	145.0	-
1,2,3,4-TETRACHLOROBENZENE	0.20	50.7 - 107.7	3	76.7	0.4	2	72.5	0.6	-	-	-	-	-	-	1	105.0	-	2	87.5	0.2	1	85.0	-
2-CHLORONAPHTHALENE	0.20	31.7 - 98.5	3	78.3	0.8	2	55.0	1.5	-	-	-	-	-	-	1	65.0	-	2	62.5	0.7	1	35.0	-
ALPHA-BHC	0.20	40.0 - 125.4	3	61.7	0.2	2	52.5	0.3	-	-	-	-	-	-	1	60.0	-	2	52.5	0.3	1	70.0	-
DELTA-BHC	0.20	28.6 - 184.5	3	45.0	0.8	2	42.5	1.7	-	-	-	-	-	-	1	90.0	-	2	37.5	0.4	1	90.0	-
BETA-BHC	0.20	11.2 - 168.9	3	36.7	3.5	2	67.5	0.6	-	-	-	-	-	-	1	55.0	-	2	242.5	2.6	1	95.0	-
GAMMA-BHC	0.20	35.1 - 120.0	3	61.7	1.0	2	67.5	0.6	-	-	-	-	-	-	1	70.0	-	2	80.0	0.0	1	60.0	-
1,4-DIBROMOBENZENE	-	51.0 - 104.0	3	78.0	4.6	2	88.7	7.1	-	-	-	-	-	-	1	77.0	-	2	98.0	0.4	1	77.4	-
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	3	79.8	7.7	2	82.3	6.2	-	-	-	-	-	-	1	81.6	-	2	117.0	12.7	1	84.8	-
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	3	74.0	2.5	2	96.5	6.4	-	-	-	-	-	-	1	73.0	-	2	97.9	11.5	1	73.1	-

TABLE 1f

SPIKE LEVEL F

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WINDOW	LAB 1			LAB 2			LAB 3			LAB 4			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	0.50	56.4 - 170.5	3	108.0	0.0	2	116.0	0.6	1	108.0	-	1	116.0	-	2	95.0	1.9	2	110.0	9.0	5	152.0	2.6
1,2,4-TRICHLOROBENZENE	0.50	53.9 - 162.2	3	69.3	1.1	2	89.0	5.2	1	106.0	-	1	76.0	-	2	109.0	2.3	2	80.0	5.3	5	75.6	3.1
1,2,3,4-TETRACHLOROBENZENE	0.50	50.7 - 107.7	3	57.3	2.2	2	75.0	4.2	1	88.0	-	1	52.0	-	2	85.0	0.4	2	66.0	1.1	5	58.8	5.1
2-CHLORONAPHTHALENE	0.50	31.7 - 98.5	3	58.7	2.5	2	41.0	4.3	1	56.0	-	1	58.0	-	2	52.0	0.0	2	68.0	4.2	5	54.8	7.7
ALPHA-BHC	0.50	40.0 - 125.4	3	55.3	0.5	2	80.0	2.7	1	76.0	-	1	56.0	-	2	74.0	0.0	2	55.0	1.9	5	52.8	7.4
DELTA-BHC	0.50	28.6 - 184.5	3	51.3	0.6	2	64.0	3.3	1	84.0	-	1	30.0	-	2	75.0	0.5	2	49.0	3.6	5	51.6	4.2
BETA-BHC	0.50	11.2 - 168.9	3	58.7	3.4	2	84.0	4.2	1	60.0	-	1	30.0	-	2	71.0	1.5	2	70.0	2.0	5	69.2	5.8
GAMMA-BHC	0.50	35.1 - 120.0	3	55.3	1.4	2	84.0	5.9	1	82.0	-	1	40.0	-	2	87.0	0.4	2	58.0	1.2	5	60.0	9.9
1,4-DIBROMOBENZENE	-	51.0 - 104.0	3	75.7	10.3	2	100.8	3.2	1	68.0	-	1	81.7	-	2	73.2	0.9	2	86.3	2.1	5	84.0	12.1
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	3	75.3	13.3	2	122.5	0.7	1	98.1	-	1	76.3	-	2	77.6	1.2	2	110.0	15.5	5	86.6	15.5
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	3	71.0	7.2	2	105.5	0.7	1	94.3	-	1	79.1	-	2	76.9	4.5	2	93.9	4.0	5	82.4	13.5

SUMMARY TABLE FOR LOVE CANAL SOIL BQC SAMPLES BY SPIKE LEVEL

TABLE 1g

SPIKE LEVEL G

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WINDOW	LAB 1			LAB 2			LAB 3			LAB 4			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	2.00	42.3 - 112.2	4	47.0	158.9	-	-	-	2	43.5	234.1	1	57.5	-	1	62.5	-	1	49.0	-	2	82.5	17.1
1,2,4-TRICHLOROBENZENE	2.00	45.6 - 109.3	4	52.9	39.2	-	-	-	2	61.3	6.9	1	51.0	-	1	78.5	-	1	50.0	-	2	63.0	18.0
1,2,3,4-TETRACHLOROBENZENE	2.00	44.3 - 93.3	4	57.9	13.3	-	-	-	2	67.0	109.8	1	43.5	-	1	74.5	-	1	53.5	-	2	64.5	8.8
2-CHLORONAPHTHALENE	2.00	30.6 - 74.8	4	41.6	40.5	-	-	-	2	38.3	166.4	1	38.5	-	1	49.5	-	1	37.0	-	2	30.8	4.6
ALPHA-BHC	2.00	37.1 - 116.2	4	59.3	40.2	-	-	-	2	80.0	152.0	1	42.0	-	1	80.0	-	1	51.5	-	2	76.5	18.5
DELTA-BHC	2.00	17.8 - 148.2	4	51.5	18.2	-	-	-	2	76.0	152.6	1	27.0	-	1	80.0	-	1	51.5	-	2	60.8	86.1
BETA-BHC	2.00	44.6 - 128.0	4	57.8	40.6	-	-	-	2	82.8	165.8	1	32.5	-	1	75.0	-	1	61.0	-	2	83.8	15.2
GAMMA-BHC	2.00	42.4 - 122.6	4	59.4	44.5	-	-	-	2	87.8	162.8	1	37.5	-	1	89.0	-	1	56.5	-	2	82.8	18.8
1,4-DIBROMOBENZENE	-	51.0 - 104.0	4	73.9	2.8	-	-	-	2	70.7	9.3	1	75.2	-	1	79.5	-	1	92.7	-	2	75.6	4.7
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	4	82.4	2.9	-	-	-	2	86.8	2.6	1	76.9	-	1	90.2	-	1	109.0	-	2	80.4	12.7
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	4	71.9	4.8	-	-	-	2	89.7	18.9	1	74.1	-	1	95.5	-	1	88.3	-	2	79.7	2.8

SUMMARY TABLE FOR LOVE CANAL SAND BQC SAMPLES BY SPIKE LEVEL *

TABLE 1h

SPIKE LEVEL A

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WINDOW	LAB 1			LAB 2			LAB 3			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	0.60	56.4 - 170.5	2	83.3	33.9	2	76.7	3.1	2	81.7	31.7	2	97.5	18.1	1	90.0	-	2	145.8	13.7
1,2,4-TRICHLOROBENZENE	0.45	53.9 - 162.2	2	54.4	26.0	2	36.7	4.3	2	75.6	16.6	2	87.8	23.3	1	84.4	-	2	92.2	22.2
1,2,3,4-TETRACHLOROBENZENE	0.50	50.7 - 107.7	2	44.0	12.9	2	24.0	0.0	2	57.0	27.3	2	79.0	16.1	1	88.0	-	2	78.0	43.5
2-CHLORONAPHTHALENE	0.40	31.7 - 98.5	2	65.0	16.3	2	31.3	5.7	2	61.2	26.0	2	83.8	23.2	1	87.5	-	2	85.0	41.6
ALPHA-BHC	0.70	40.0 - 125.4	2	56.4	48.3	2	23.6	4.3	2	52.1	5.8	2	80.7	11.3	1	97.1	-	2	70.0	31.7
DELTA-BHC	0.60	28.6 - 184.5	2	53.3	48.6	2	25.8	4.6	2	43.3	5.4	2	84.2	4.2	1	71.7	-	2	73.3	45.0
BETA-BHC	0.75	11.2 - 168.9	2	60.7	45.1	2	26.0	3.6	2	56.7	8.3	2	84.0	6.7	1	100.0	-	2	90.7	31.2
GAMMA-BHC	0.65	35.1 - 120.0	2	55.4	51.1	2	30.0	3.6	2	53.8	0.0	2	80.8	1.3	1	96.9	-	2	74.6	39.4
1,4-DIBROMOBENZENE	-	51.0 - 104.0	2	80.4	7.3	2	95.1	1.0	2	85.7	3.4	2	85.3	11.2	1	79.7	-	2	100.5	0.7
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	2	83.2	30.3	2	116.5	1.8	2	101.5	0.7	2	79.5	19.3	1	105.0	-	2	96.3	17.3
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	2	76.4	33.4	2	90.5	8.7	2	92.5	3.5	2	78.1	6.5	1	104.0	-	2	99.8	3.2

TABLE 1i

SPIKE LEVEL B

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WINDOW	LAB 1			LAB 2			LAB 3			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	1.20	42.3 - 112.2	2	63.3	0.0	3	57.5	6.3	3	68.6	5.6	1	81.7	-	-	-	-	1	110.8	-
1,2,4-TRICHLOROBENZENE	0.90	45.6 - 109.3	2	49.4	1.6	3	45.6	21.1	3	78.9	6.5	1	76.7	-	-	-	-	1	80.0	-
1,2,3,4-TETRACHLOROBENZENE	1.00	44.3 - 93.3	2	45.5	1.6	3	37.7	16.9	3	66.3	5.3	1	76.0	-	-	-	-	1	84.0	-
2-CHLORONAPHTHALENE	0.80	30.6 - 74.8	2	46.3	3.8	3	35.4	17.4	3	59.6	8.5	1	73.7	-	-	-	-	1	80.0	-
ALPHA-BHC	1.40	37.1 - 116.2	2	47.5	3.2	3	38.8	17.1	3	72.4	11.1	1	66.4	-	-	-	-	1	85.7	-
DELTA-BHC	1.20	17.8 - 148.2	2	44.2	10.7	3	28.1	14.0	3	71.1	15.3	1	67.5	-	-	-	-	1	55.8	-
BETA-BHC	1.50	44.6 - 128.0	2	51.0	2.8	3	38.9	22.3	3	87.1	12.5	1	71.3	-	-	-	-	1	85.3	-
GAMMA-BHC	1.30	42.4 - 122.6	2	48.1	5.7	3	43.8	16.7	3	85.9	13.9	1	69.2	-	-	-	-	1	83.1	-
1,4-DIBROMOBENZENE	-	51.0 - 104.0	2	76.6	0.0	3	86.4	2.6	3	78.3	11.6	1	75.5	-	-	-	-	1	103.0	-
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	2	75.4	2.1	3	103.2	15.3	3	103.7	13.1	1	74.5	-	-	-	-	1	118.0	-
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	2	73.0	5.2	3	92.0	4.3	3	96.1	1.6	1	66.6	-	-	-	-	1	94.1	-

* LAB 4 did not analyze sand BQC samples.

SUMMARY TABLE FOR LOVE CANAL SAND BQC SAMPLES BY SPIKE LEVEL *

TABLE 1j

SPIKE LEVEL C

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WINDOW	LAB 1			LAB 2			LAB 3			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	1.80	42.3 - 112.2	2	56.1	32.2	3	57.2	16.3	3	55.2	32.0	3	76.1	10.9	1	98.3	-	2	87.8	1.8
1,2,4-TRICHLOROBENZENE	1.35	45.6 - 109.3	2	50.0	51.3	3	52.6	11.2	3	51.4	40.8	3	75.1	11.4	1	84.4	-	2	71.1	10.3
1,2,3,4-TETRACHLOROBENZENE	1.50	44.3 - 93.3	2	47.0	63.2	3	42.7	16.2	3	52.0	40.0	3	73.3	13.1	1	90.0	-	2	66.7	1.4
2-CHLORONAPHTHALENE	1.20	30.6 - 74.8	2	57.1	63.0	3	34.7	11.1	3	46.1	37.1	3	71.7	16.0	1	77.5	-	2	62.1	0.9
ALPHA-BHC	2.10	37.1 - 116.2	2	57.9	44.8	3	38.1	2.2	3	50.3	30.6	3	70.2	11.3	1	86.2	-	2	62.4	3.2
DELTA-BHC	1.80	17.8 - 148.2	2	55.3	57.6	3	32.6	5.2	3	47.4	25.6	3	69.1	8.2	1	77.2	-	2	35.0	2.2
BETA-BHC	2.25	44.6 - 128.0	2	62.2	51.5	3	53.8	5.2	3	56.1	28.2	3	73.2	12.3	1	96.4	-	2	62.2	1.0
GAMMA-BHC	1.95	42.4 - 122.6	2	55.6	42.4	3	45.5	9.6	3	54.7	26.4	3	72.1	9.5	1	93.3	-	2	67.7	11.8
1,4-DIBROMOBENZENE	-	51.0 - 104.0	2	85.9	1.4	3	93.0	2.9	3	80.1	1.7	3	77.0	11.6	1	94.4	-	2	103.4	9.1
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	2	91.5	9.0	3	94.3	7.6	3	93.1	12.9	3	81.4	10.7	1	119.0	-	2	90.4	24.4
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	2	84.4	6.0	3	87.2	5.6	3	90.1	3.0	3	84.7	15.2	1	109.0	-	2	91.5	5.6

TABLE 1k

SPIKE LEVEL D

ANALYTE	SPIKE CONC. (ug/kg)	% RECOVERY ACCEPTANCE WINDOW	LAB 1			LAB 2			LAB 3			LAB 6			LAB 7			LAB 8		
			N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD	N	MEAN	%RSD
1,2-DICHLOROBENZENE	2.40	42.3 - 112.2	1	24.2	-	-	-	-	2	74.6	0.8	1	46.7	-	1	93.3	-	1	64.2	-
1,2,4-TRICHLOROBENZENE	1.80	45.6 - 109.3	1	26.7	-	-	-	-	2	75.3	1.6	1	53.3	-	1	80.0	-	1	53.3	-
1,2,3,4-TETRACHLOROBENZENE	2.00	44.3 - 93.3	1	35.0	-	-	-	-	2	75.0	0.9	1	50.5	-	1	83.0	-	1	53.5	-
2-CHLORONAPHTHALENE	1.60	30.6 - 74.8	1	41.9	-	-	-	-	2	59.1	0.7	1	46.9	-	1	76.3	-	1	46.9	-
ALPHA-BHC	2.80	37.1 - 116.2	1	41.4	-	-	-	-	2	82.3	2.1	1	48.6	-	1	73.6	-	1	48.9	-
DELTA-BHC	2.40	17.8 - 148.2	1	38.3	-	-	-	-	2	60.6	2.4	1	47.5	-	1	74.6	-	1	35.4	-
BETA-BHC	3.00	44.6 - 128.0	1	47.3	-	-	-	-	2	86.7	8.2	1	51.7	-	1	93.0	-	1	49.7	-
GAMMA-BHC	2.60	42.4 - 122.6	1	44.2	-	-	-	-	2	88.3	3.4	1	53.8	-	1	99.2	-	1	49.2	-
1,4-DIBROMOBENZENE	-	51.0 - 104.0	1	75.2	-	-	-	-	2	80.0	0.5	1	84.5	-	1	82.9	-	1	100.0	-
2,4,6-TRIBROMOBIPHENYL	-	56.0 - 126.0	1	70.7	-	-	-	-	2	91.1	2.5	1	92.8	-	1	92.1	-	1	114.0	-
1,2,4,5-TETRABROMOBENZENE	-	50.0 - 115.0	1	63.5	-	-	-	-	2	91.5	0.5	1	74.7	-	1	83.1	-	1	95.5	-

* LAB 4 did not analyze sand BQC samples.

LOVE CANAL SUMMARY SOIL BQC STATISTICS TABLE BY LABORATORY

TABLE 2a

ANALYTE	LAB 1			LAB 2			LAB 3			LAB 4			LAB 6			LAB 7			LAB 8		
	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD
1,2-DICHLOROBENZENE	30	90.8	40.5	38	85.3	21.8	22	76.0	56.2	6	76.3	0.0	22	87.6	39.4	18	83.8	21.7	20	118.7	31.7
1,2,4-TRICHLOROBENZENE	30	73.5	16.2	38	76.5	16.6	22	90.9	21.6	6	67.8	0.4	22	89.0	13.1	18	76.3	10.3	20	81.1	11.9
1,2,3,4-TETRACHLOROBENZENE	30	63.2	16.8	38	64.8	22.2	22	79.6	28.6	6	50.3	1.4	22	82.3	17.8	18	69.4	19.9	20	67.0	16.5
2-CHLORONAPHTHALENE	30	54.0	15.6	38	49.7	11.3	22	43.7	50.9	6	51.6	1.5	22	53.1	36.6	18	51.0	15.7	20	44.9	27.7
ALPHA-BHC	30	61.1	31.8	38	61.2	36.7	22	74.4	66.0	6	55.7	7.9	22	78.0	52.2	18	60.4	68.7	20	71.3	45.7
DELTA-BHC	30	51.5	19.6	38	49.9	42.0	22	72.9	79.7	6	35.6	10.2	22	78.2	63.6	18	55.6	45.2	20	66.3	48.2
BETA-BHC	30	55.4	17.5	38	57.9	67.3	22	77.9	85.3	6	43.2	12.8	22	86.4	175.2	18	91.0	66.1	20	76.4	60.1
GAMMA-BHC	30	59.3	29.1	38	60.7	37.7	22	78.6	76.3	6	45.7	5.1	22	83.2	45.9	18	65.6	48.0	20	73.7	38.9
1,4-DIBROMOBENZENE	30	72.9	4.9	38	87.1	9.1	22	68.1	5.9	6	76.6	1.1	22	76.7	6.5	18	86.2	8.7	20	82.4	8.6
2,4,6-TRIBROMOBIPHENYL	30	76.8	9.0	38	98.3	10.8	22	93.8	11.3	6	79.4	12.9	22	90.1	11.9	18	105.7	22.3	20	91.9	11.1
1,2,4,5-TETRABROMOBENZENE	30	69.9	7.6	38	87.5	9.5	22	108.9	43.5	6	74.7	1.4	22	85.1	18.8	18	88.0	14.1	20	86.8	13.2

LOVE CANAL SUMMARY SAND BQC STATISTICS TABLE BY LABORATORY *

TABLE 2b

ANALYTE	LAB 1			LAB 2			LAB 3			LAB 6			LAB 7			LAB 8		
	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD	N	MEAN % REC.	MEAN % RSD
1,2-DICHLOROBENZENE	7	61.4	22.0	8	62.2	9.3	10	68.4	17.8	7	78.8	13.8	3	93.9	-	6	107.0	5.2
1,2,4-TRICHLOROBENZENE	7	47.8	26.3	8	46.0	13.2	10	69.2	17.8	7	75.8	16.2	3	83.0	-	6	76.7	10.8
1,2,3,4-TETRACHLOROBENZENE	7	44.0	25.9	8	36.1	12.4	10	61.9	19.2	7	72.1	14.3	3	87.0	-	6	71.1	15.0
2-CHLORONAPHTHALENE	7	54.1	27.7	8	34.1	12.1	10	55.8	19.0	7	71.9	18.9	3	80.4	-	6	70.2	14.2
ALPHA-BHC	7	52.1	32.1	8	34.7	8.3	10	63.7	14.1	7	69.6	11.3	3	85.6	-	6	66.6	11.7
DELTA-BHC	7	49.1	39.0	8	29.2	8.4	10	56.3	13.8	7	70.1	6.6	3	74.5	-	6	51.3	15.7
BETA-BHC	7	56.4	33.1	8	41.3	11.2	10	71.6	15.5	7	72.9	10.1	3	96.5	-	6	73.5	10.7
GAMMA-BHC	7	51.8	33.0	8	41.0	10.8	10	70.6	12.7	7	71.6	6.2	3	96.5	-	6	69.5	17.0
1,4-DIBROMOBENZENE	7	80.1	2.9	8	91.0	2.3	10	80.6	4.8	7	80.2	11.5	3	85.7	-	6	101.8	3.3
2,4,6-TRIBROMOBIPHENYL	7	81.5	13.8	8	103.2	9.1	10	97.6	8.4	7	81.5	14.1	3	105.4	-	6	100.9	13.9
1,2,4,5-TETRABROMOBENZENE	7	75.9	14.9	8	89.8	5.9	10	92.6	2.2	7	78.8	11.7	3	98.7	-	6	95.3	2.9

* LAB 4 did not analyze sand BQC samples.

LOVE CANAL SUMMARY SOIL BQC STATISTICS TABLE

TABLE 3a

ANALYTE	ALL LABS		
	N	MEAN % REC.	MEAN % RSD
1,2-DICHLOROBENZENE	156	89.1	33.1
1,2,4-TRICHLOROBENZENE	156	79.9	14.8
1,2,3,4-TETRACHLOROBENZENE	156	69.3	19.6
2-CHLORONAPHTHALENE	156	49.8	23.5
ALPHA-BHC	156	66.4	45.8
DELTA-BHC	156	59.6	46.0
BETA-BHC	156	69.9	72.3
GAMMA-BHC	156	67.8	42.7
1,4-DIBROMOBENZENE	156	79.1	7.0
2,4,6-TRIBROMOBIPHENYL	156	91.7	12.1
1,2,4,5-TETRABROMOBENZENE	156	86.3	15.9

LOVE CANAL SUMMARY SAND BQC STATISTICS TABLE

TABLE 3b

ANALYTE	ALL LABS		
	N	MEAN % REC.	MEAN % RSD
1,2-DICHLOROBENZENE	41	75.3	13.1
1,2,4-TRICHLOROBENZENE	41	64.3	16.0
1,2,3,4-TETRACHLOROBENZENE	41	58.7	16.5
2-CHLORONAPHTHALENE	41	57.9	17.2
ALPHA-BHC	41	59.1	14.5
DELTA-BHC	41	52.8	15.7
BETA-BHC	41	65.4	16.0
GAMMA-BHC	41	63.5	15.2
1,4-DIBROMOBENZENE	41	86.0	4.5
2,4,6-TRIBROMOBIPHENYL	41	94.2	11.0
1,2,4,5-TETRABROMOBENZENE	41	87.7	6.4

SUMMARY OF FLAGS USED TO QUALIFY BQC SAMPLE DATA FROM TABLE 1

TABLE 4

	LAB 1	LAB 2	LAB 3	LAB 4	LAB 6	LAB 7	LAB 8
1,2-DICHLOROBENZENE		M(1)					
1,2,4-TRICHLOROBENZENE		M(1)					
1,2,3,4-TETRACHLOROBENZENE							
2-CHLORONAPHTHALENE			B(1)			M(4)	
ALPHA-BHC		M(2)	M(1)				H(2)
DELTA-BHC		M(5)	M(3) I(1)	S(1)	I(1)	M(6)	H(2) M(1)
BETA-BHC	B(1)	M(1)	B(1)		I(3) H(1) B(1) S(2)	I(2) H(2) M(7) T(1)	Y(3) X(2) H(1) Z(1)
GAMMA-BHC		M(1)	I(2) R(1)		H(1) S(1)	M(14) H(1)	H(9)

B ND on Form I due to ion ratio and scan range
H Quantitated by peak height
I ND on Form I due to ion ratio
M Used manual override
R ND on Form I due to RRT
S ND on Form I due to scan range

T ND on Form I due to ion ratio and used manual override
X ND on Form I due to scan range and used peak height for quantitation
Y ND on Form I due to ion ratio and used secondary ion for quantitation
Z ND on Form I due to ion ratio and scan range and used secondary ion for quantitation

Number in parenthesis (#) indicates number of incidences.

COUNT OF DATA VALIDATION SUMMARY QUALIFIERS FROM FIELD SAMPLES IN FORM I DATABASE

TABLE 5a

FLAG	LAB 1	LAB 2	LAB 3	LAB 6	LAB 7	LAB 8	TOTAL
G	1351	991	708	852	922	689	5513
U	45	110	471	409	57	435	1527
B	212	139	53	11	21	132	568
X	0	0	0	0	0	0	0
TOTAL	1608	1240	1232	1272	1000	1256	7608

PERCENTAGE OF G, U, B FLAGS

FLAG	LAB 1	LAB 2	LAB 3	LAB 6	LAB 7	LAB 8	TOTAL
G	84.0	79.9	57.5	67.0	92.2	54.9	72.4
U	2.8	8.9	38.2	32.1	5.7	34.6	20.1
B	13.2	11.2	4.3	0.9	2.1	10.5	7.5

NOTE: The numbers represent analytes, not samples.
The counts for Lab 1 include the qualifiers for Lab 4.

COUNT OF DATA VALIDATION INDIVIDUAL QUALIFIERS FROM FIELD SAMPLES IN FORM I DATABASE

TABLE 5b

FLAG(S)	LAB 1	LAB 2	LAB 3	LAB 6	LAB 7	LAB 8	TOTAL
E1	87	36	25	0	30	43	221
E3+E5+E8	0	0	6	44	8	20	78
E7	0	66	5	0	0	14	85
I2+I4	0	6	4	0	88	3	101
I3+I5	0	0	0	7	0	9	16
H1+H2+H3+H4	8	256	784	520	8	656	2232
K2	0	0	0	0	0	6	6
Q1	0	4	3	2	0	2	11
Q6+Q7	0	1	7	7	7	2	24
Q8	0	0	8	0	0	16	24
QA	1	0	0	0	0	0	1
Z1	80	16	16	0	8	40	160
Z2	56	0	56	0	0	40	152
Z7	56	0	48	0	0	56	160
Z9	136	120	8	0	0	0	264
ZB	0	0	0	0	0	48	48
ZC	0	0	0	0	0	40	40
ZD	0	0	24	0	0	0	24
ZE	0	0	0	0	0	104	104
ZH+ZI	0	48	0	0	0	0	48
ZJ	0	0	8	0	0	0	8
TOTAL	424	553	1002	580	149	1099	3807

NOTE: The numbers represent analytes, not samples.
The counts for Lab 1 include the qualifiers for Lab 4.

SAMPLE PERCENT RECOVERY USED IN THE
THE GENERATION OF THE LOW LEVEL PREDICTION INTERVALS

TABLE 6

PE SET 1

SAMPLE ID LAB LOGIN ID	1004 B74644S	1004 B74645S	6004 091187C06	6004 091187C15	7004 09674R10	7004 09674R11	8004 0811704A	8004 0811704C
1,2-DICHLOROBENZENE	230	204	104	118	70	74	134	144
1,2,4-TRICHLOROBENZENE	126	94	112	112	70	68	82	64
1,2,3,4-TETRACHLOROBENZENE	100	78	88	96	64	62	80	50
2-CHLORONAPHTHALENE	84	38	86	88	52	52	66	56
ALPHA-BHC	114	94	0	106	48	74	82	48
DELTA-BHC	122	88	128	172	56	0	118	72
BETA-BHC	134	104	0	0	62	56	84	58
GAMMA-BHC	136	108	0	0	60	68	102	142

PE SET 2

SAMPLE ID LAB LOGIN ID	1007 75551	1011 75552	2020 D0783	2015 D0782	3014 37571R	3008 37565R	4001 17091435	4006 17091440	6011 092687C12	6012 092687C14	7004 09806004	7011 09806011	8010 918803A	8015 918804A
1,2-DICHLOROBENZENE	102	95	85	90	118	110	153	145	108	112	103	100	172	132
1,2,4-TRICHLOROBENZENE	96	100	107	100	138	140	147	131	107	116	98	116	160	93
1,2,3,4-TETRACHLOROBENZENE	68	68	74	88	92	88	72	68	94	100	80	86	78	68
2-CHLORONAPHTHALENE	60	58	52	60	102	85	50	68	58	72	72	65	58	50
ALPHA-BHC	73	73	70	83	123	0	66	66	0	84	93	86	97	91
DELTA-BHC	68	82	63	62	145	0	0	85	120	0	113	125	167	132
BETA-BHC	65	71	44	57	0	0	0	76	173	143	117	119	89	79
GAMMA-BHC	77	77	49	71	55	0	65	77	200	55	88	80	111	98

NOTE: ALL REPORTED ZERO VALUES WERE NOT USED IN GENERATION OF PREDICTION INTERVALS

SAMPLE PERCENT RECOVERY USED IN THE
GENERATION OF THE HIGH LEVEL PREDICTION INTERVALS

TABLE 7

PE SET 1

SAMPLE ID	1001	1001	6001	6001	7001	7001	8001	8001	1005	1005	6005	6005	7005	7005	8005	8005
LAB LOGIN ID	B74635S	B74636S	091187C08	091187C16	096740T1	096740T2	0811701C	0811701B	B74647S	B74648S	091187C11	091187C12	09674R13	09674R14	0811705B	0811705C
1,2-DICHLOROBENZENE	97	99	74	62	54	61	59	62	113	113	90	74	64	57	76	69
1,2,4-TRICHLOROBENZENE	76	80	80	69	61	67	39	60	87	89	91	84	70	57	62	44
1,2,3,4-TETRACHLOROBENZENE	66	66	82	67	54	56	44	71	71	77	80	76	66	47	72	41
2-CHLORONAPHTHALENE	51	49	61	54	40	41	38	42	52	63	69	61	56	50	48	35
ALPHA-BHC	67	84	98	90	51	62	47	69	73	88	99	91	63	40	59	44
DELTA-BHC	71	77	124	113	65	77	57	103	48	60	93	104	44	27	58	56
BETA-BHC	80	92	101	98	0	83	53	62	99	116	131	113	76	0	74	64
GAMMA-BHC	79	90	106	88	47	76	56	75	89	110	110	98	81	61	78	59

PE SET 2

SAMPLE ID	1019	1002	2005	2009	3002	3017	4005	4017	6008	6009	7002	7012	8001	8008
LAB LOGIN ID	75553	75695	D0780	D0781	37559R	37559R	17091439	17091451	100387C04	100387C05	09806002	09806012	918801A	918802A
1,2-DICHLOROBENZENE	76	61	74	74	58	73	94	93	83	86	77	56	93	95
1,2,4-TRICHLOROBENZENE	83	68	89	84	70	84	101	97	93	95	77	92	87	87
1,2,3,4-TETRACHLOROBENZENE	69	58	78	77	64	76	73	70	89	88	76	61	77	72
2-CHLORONAPHTHALENE	60	48	48	54	58	62	48	43	72	78	65	53	39	43
ALPHA-BHC	84	58	73	64	85	96	67	75	109	107	75	82	101	98
DELTA-BHC	112	55	66	66	61	69	70	81	113	115	93	99	153	159
BETA-BHC	83	65	59	61	0	0	95	101	0	0	90	99	88	88
GAMMA-BHC	83	63	65	58	78	89	65	72	117	115	70	85	108	103

NOTE: ALL REPORTED ZERO VALUES WERE NOT USED IN THE GENERATION OF THE CONFIDENCE INTERVALS

REVISED 11/24/87

THE EMSL-LV DATA VALIDATION STANDARD OPERATING PROCEDURE FOR THE LOVE CANAL EMERGENCY DECLARATION AREA HABITABILITY STUDY SOIL ASSESSMENT -- INDICATOR CHEMICALS

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LCHSSA Data Validation Standard Operating Procedure

The EMSL-LV has been tasked to qualify all the data generated by the seven laboratories participating in the Love Canal Emergency Declaration Area Habitability Study, Soil Assessment (LCHSSA). A database will be generated from the validated and qualified Form I's. This SOP is designed to assist the data evaluator in organizing the validation process and generating the appropriate deliverables for this enormous task. It is important that the data evaluator be completely familiar with the SOW, in particular, the method, QA criteria, and deliverable requirements. The text of this SOP is followed by illustrations that are intended to assist in the validation, such as Data Validation Checklists, Summary of the QA Criteria, and Form I with qualifiers. Remember to be patient and thorough.

1. LOGIN - All data packages received must be logged into the Data Package Login Book - include lab name, date of receipt, floppy disks received, size of package, pages, courier, and the initials of the person doing the login. (See illustration 1)

2. CASE NARRATIVE - Read the Case Narrative carefully and note anything unusual and sample specific information. For example, note any instrumentation problems, contamination problems, decisions made by Project Management Staff, samples broken or lost from sample receipt through analysis, and samples that required reextraction or reanalysis and why.

3. QC SUMMARY - Spend a short time reviewing the QC Summary data to get a feel for the data quality, problems encountered such as surrogates or internal standards out of criteria, frequency of initial calibrations, and number of reextractions and reanalyses. Also, note carefully if the forms are properly completed.

4. FLOPPY DISK - Merge the floppy diskettes received with the data package into the Data Validation software. See the Data Validation System User's Guide prepared by the software contractor for instructions on how to perform the merge. Login the merge of the diskettes into the Love Canal Login Book. Print out the Summary Concentration Report by Sample ID, Error Listing of Samples/Analyses, and Audit Trail. Examine the information on all

of the reports, note any unusual incidences, compare the error messages to the comments in the Case Narrative, and compare some of the concentration values to the values on the Form I. Refer back to these summary tables throughout the data validation process. See illustrations 2-5 for examples of the reports.

5. DATA VALIDATION SOFTWARE (DVS) - The DVS was developed with the concept of a shift as the basis. It is important to understand this idea as the entire validation process will be organized by shift. An analytical shift in DVS is the same as outlined in the SOW, Exhibit B, Section 3.2.2, except, for software purposes, a 16 hour analytical run is composed of two shifts. The first data to review is from an initial calibration. The initial calibration is associated with many shifts as well as being analyzed within a shift; therefore, it is treated uniquely. Print the Validation Review for the first initial calibration (Initial Calibration Checklist). Then print the Validation Review for the first shift file name (Shift Results Checklist). Finally, print the Sample Checklists for all samples analyzed within the first shift. Print the Validation Reviews for the remaining initial calibrations, shifts and samples as above. See the Data Validation System User's Guide prepared by the software contractor for details on how to use the Data Validation software and print the reports. See illustrations 6 - 8 for a copy of the Initial Calibration, Shift Results and Sample Checklists generated by the DVS.

6. ORGANIZATION OF DATA PACKAGE - Arrange and label the data package by shifts.

   a) For a shift with an initial calibration, include the following items in the order specified: Form V (Performance Check Solution Summary), Form VII (Continuing Calibration Check), Form VIa (Initial Calibration Data), Form II (Surrogate Percent Recovery Summary), and Form X's (Internal Standard Response and Retention Time). For the raw data and remaining forms, put the data in order of date and time of analysis and put the sample specific forms with the corresponding raw data. The remaining data must include the raw data for IC1 - IC5, Form VIb (EPA Check Standard Summary) and the raw data for the EPA Check Standard, Form IV (Blank Summary) and the Form I and raw data for the blank if one was analyzed in the shift, Form III (Matrix Spike/Matrix Spike Duplicate Recovery Summary) and the Form I's and raw data for the MS and/or MSD samples if they were analyzed in the shift and all other Form I's and sample raw data analyzed in the shift. The end of the shift is marked by the raw data for the PC2 analysis.

b) For a shift without an initial calibration, include the following items in the order specified: Form V (Performance Check Solution Summary), Form VII (Continuing Calibration Check), Form II (Surrogate Percent Recovery Summary), and Form X's (Internal Standard Response and Retention Time). For the raw data and remaining forms, put the data in order of date and time of analysis and put the sample specific forms with the corresponding raw data. The remaining data must include Form VIb (EPA Check Standard Summary) and the raw data for the EPA Check Standard if one was analyzed in the shift, Form IV (Blank Summary) and the Form I and the raw data for the blank if one was analyzed in the shift, Form III (Matrix Spike/Matrix Spike Duplicate Recovery Summary) and the Form I's and the raw data for the MS and/or MSD samples if they were analyzed in the shift and all other Form I's and the sample raw data analyzed in the shift. The end of the shift is marked by the raw data for the PC2 analysis.

When a shift is complete, label it with the shift file name. Check each Form I to make sure that all the samples have the same shift file name. Also, check for missing forms or raw data by comparing the sample raw data to Forms II and X's. Arrange the shifts in order of date and time of analysis and place in a labeled banker box in that order. Include the lab name, data package number and LCHSSA on the label of the box.

RESUBMISSION REQUESTS - If any form or raw data is missing, you may call the laboratory and request the necessary resubmissions. When requesting resubmissions, provide the laboratory with the shift file name and all other pertinent information. Record the phone call on a Record of Telephone Conversation Form and place in the Love Canal Phone Log. If the list is very long, FAX the list to the laboratory. Please make all requests to the Project Manager of that laboratory. See illustration 9 for a Record of Telephone Conversation Form.

It may be necessary during the data validation process to use the Summary of QA Criteria, illustration 10, and the List of Data Qualifiers.

7. INITIAL CALIBRATION - The initial calibration documents the linearity of the instrument within the calibration range of the method, establishes the relative response factors on which the continuing calibration acceptance criteria are based, and verifies the performance of the column before samples are analyzed. It is important to check the initial calibration thoroughly as it impacts all samples analyzed until the next initial calibration. Check the following items from the initial calibration:

The DVS has areas that need to be completed by the data evaluator. The options for the answers are: Y = yes, acceptable data; P = problem encountered with the data; X = question is not applicable. See the Data Validation Systems User's Guide.

a) Compare the information on the Form VI to the raw data. Do the dates, times, instrument ID, and file names match? Spot check the relative response factor (RRF), mean RRF, and percent relative standard deviation (%RSD) calculations.

b) Does the Error Listings Report indicate any analyses out of criteria? Compare the information from this report and check the Form VI to see if the %RSD criteria are met. If the numbers are close to the QC limits, check the calculations carefully.

c) Check the quantitation reports for evidence of editing - manual quantitation.

d) Examine the SICPs for interference, peak shape and reasonableness. Note any problems on the DVS Initial Calibration Checklist.

e) Are resubmissions needed? For example, resubmissions may be necessary if the SICPs are not displayed on the appropriate scale or the Form VI is not completed correctly.

f) If the IC2 is used for the PC1 of the shift, the date and time of analysis on Form VI for the IC2 must match that on Form V for PC1 and the RRF data on Form VI for IC2 must match that on Form VII.

8. SHIFT RESULTS - A shift consists of a PC1, QC samples, field samples, and a PC2. The quality of the field sample data within a shift is impacted by the PC1, the QC sample results, and the PC2. Therefore, the DVS Shift Results Checklist asks which QC data is associated with the field samples. It is important to evaluate the information in the Shift Results Checklist prior to evaluating the field samples in a shift. See illustration 7 for the Shift Results Checklist.

   a) Deliverables - If any forms or raw data are missing from the shift, list them on the DVS checklist in the space provided. Complete the date resolved when the deliverables are received.

   b) Performance Check 1 (PC1): The performance check solution is analyzed to demonstrate column performance - resolution and sensitivity - and must be analyzed at the proper frequency.

- Complete the date and time of analysis of the PC1. Is the PC1 analyzed at the proper time interval?
- Is this PC1 a PC2 midpoint from the previous shift? If yes, what is the shift file name from the previous shift? It is important to complete this question for checking if the appropriate QC samples were analyzed at the proper frequency. See SOW, Exhibit B, Sec 3.2 for the requirements of a 16 hour analytical run.
- Compare the PC1 raw data to the information on the Form V. If there are any discrepancies and can be corrected by resubmissions, request them. If they are not correctable, explain the problem on the checklist.
- Check the raw data to see if the PC1 meets the percent valley, signal-to-noise (S/N) ratio, and ion ratio criteria and that the numbers on the Form V match the raw data.
- Check the chromatography - look at peak shape, interference, and reasonableness.
- Check the quantitation report for evidence of editing and manual quantitation. Was the manual quantitation necessary due to interference or to meet criteria?
- Make any comments on the checklist, including qualifying flags, that will need to be put on all or some of the associated samples.

c) Continuing Calibration (CC): The CC solution is the same solution as the PC1, but is examined for different reasons. The CC analysis demonstrates that the RRFs have not changed more than specified in the SOW as compared to the RRFs from the initial calibration. Remember, the raw data for the PC1 and CC are the same.

- Complete the date and time of analysis of the CC, which must be the same as that for the PC1.
- Check to see if the continuing calibration is compared to the correct initial calibration.
- Compare the CC raw data to the information on the Form VII. If there are any discrepancies and can be corrected by resubmissions, request them. If they are not correctable, explain the problem on the checklist.
- Check the raw data to see if the CC meets the percent difference criteria and that the numbers on the Form VII match the raw data.
- Check the internal standard areas and retention times. Are the proper internal standard areas and retention times correct on the Forms X-I - X-V? Be careful because the Mass Spectrometer may use 100th of minutes and not seconds, 60th of minutes.
- Make any comments on the checklist, including qualifying flags, that will need to be put on all or some of the associated samples.

d) Performance Check 2 (PC2): The PC2 is analyzed to demonstrate that the column was within control throughout the time that field samples were analyzed.

- Complete the date and time of analysis of the PC2. Is the PC2 analyzed at the proper frequency?
- Compare the PC2 raw data to the information on the Form V. If there are any discrepancies that can be corrected by resubmissions, request them. If they are not correctable, explain the problem on the checklist.
- Check the raw data to see if the PC2 meets the percent valley, signal-to-noise (S/N) ratio, and ion ratio criteria and that the numbers on the Form V match the raw data.
- Check the chromatography - look at peak shape, interference, and reasonableness.
- Check the quantitation report for evidence of editing and manual quantitation. Was the manual quantitation necessary due to interference or to meet criteria?
- Make any comments on the checklist, including qualifying flags, that will need to be put on all or some of the associated samples. Explain the reason for the flag(s).

e) Blind QC Sample (BQC): The BQC sample must be analyzed with the samples from the associated extraction batch and at least one BQC sample must be analyzed in each shift (except if there is a 16 hour analytical run, or an EMPC was analyzed in the shift with rerun samples). See the SOW, Exhibit B, Secs 3.2 and 3.13. For a 16 hour analytical run, a BQC sample might only be analyzed in one of the shifts composing the 16 hour run.

- Complete the DVS checklist with the sample ID of the BQC sample analyzed in the shift. If more than one BQC sample was analyzed in a shift, make a comment on the checklist. If a BQC sample is not analyzed in the shift, put not applicable on the checklist.
- It is important to check if the correct BQC sample was analyzed with the samples. To check this, examine the extraction logbook for the date the BQC sample was extracted. Look at the Form II and determine if the samples analyzed in the shift were extracted with the BQC sample. If they were not, use the appropriate flag from the Qualifier List.
- Calculate the recovery of each analyte in the BQC sample using the sample key and determine if the recoveries are within the appropriate high or low acceptance limits. Compare the concentrations and recoveries to the data received through the RTQC system. If there are discrepancies, check the raw data to determine which value is correct and make a comment on the checklist.

- Examine the raw data and quantitation report carefully for peak shape and interference.
- Make any comments on the checklist, including qualifying flags, that will need to be put on all or some of the associated samples. Explain the reason for the flag(s).

f) EPA Check Standard (EMPC): The EMPC is analyzed with every initial calibration and at least every two weeks. It can also be analyzed in place of a BQC sample when samples from different extraction batches are reinjected. The EMPC acts as an independent verification of the standard solutions used for the project. The following items must be checked for the EMPC:

- Complete the DVS checklist with sample ID of the EMPC analyzed in the shift. If an EMPC is not analyzed in the shift, put not applicable on the checklist.
- Calculate the recovery of each analyte in the EMPC and determine if the recoveries are within the control limits. Compare the concentrations and recoveries to the data reported on the Form VIb. If there are discrepancies, check the raw data to determine which value is correct and make a comment on the checklist.
- Examine the raw data and quantitation report carefully for peak shape and interference.
- Make any comments on the checklist, including qualifying flags, that will need to be put on all or some of the associated samples.

g) Method/Holding Blank (MB): The MB is stored with the field samples and accompanies them through analysis. It is used to evaluate possible laboratory contamination. The MB must be analyzed with the samples from the associated extraction batch and at least one MB must be analyzed in each shift (except if there is a 16 hour analytical run, or if an instrument blank is analyzed with rerun samples).

- Complete the DVS checklist with the sample ID of the MB analyzed in the shift. If more than one MB was analyzed in a shift, make a comment on the checklist. If a MB is not analyzed in the shift, put not applicable on the checklist.
- It is important to check if the correct MB was analyzed with the samples. To check this, examine the extraction logbook for the date the MB was extracted. Look at the Form II and determine if the samples analyzed in the shift were extracted with the BQC sample. If they were not, use the appropriate flag from the Qualifier List.
- Calculate the concentration of each ion of each analyte in the MB and determine if the concentrations are within the

control limits. Compare the concentrations to the data on Form IV. If there are discrepancies, check the raw data to determine which value is correct and make a comment on the checklist.

- Examine the raw data and quantitation report carefully for peak shape and interference. Also look for peaks that are within the RRT windows of the LCICs and are greater than 0.5 ppb equivalent concentration (0.6 ppb for 1,2-dichlorobenzene). Check to see if the most interfering peak in each RRT window is reported on the Form IV. Try to keep in mind the contamination observed in the blank as you review the data from the associated field samples. Qualify the samples accordingly using the List of Qualifiers. Make any comments on the checklist, including qualifying flags, that will need to be put on all or some of the associated samples.

h) Matrix Spike/Matrix Spike Duplicate Sample (MS/MSD): The MS/MSD samples are extracted and analyzed at least every twenty samples. These samples are used to demonstrate the accuracy and precision of the analytical method.

- Complete the DVS checklist with the sample ID of the MS/MSD analyzed in the shift. If more than one MS/MSD were analyzed in a shift, make a comment on the checklist. If a MS/MSD was not analyzed in the shift, put not applicable on the checklist.
- Calculate the recovery of each analyte in the MS/MSD and determine if the recoveries are within the limits. Compare the concentrations and recoveries to the data reported on the Form III. If there are discrepancies, check the raw data to determine which value is correct and make a comment on the checklist.
- Examine the raw data and quantitation report carefully for peak shape and interference
- Make any comments on the checklist, including qualifying flags, that will need to be put on all or some of the associated samples. Explain the reason for the flag(s).

At this point, the Shift Results Checklist is complete. Review your comments for the shift prior to starting the individual Sample Results Checklists and keep a list of the qualifiers that will need to go on the associated samples.

9. SAMPLE RESULTS - The thorough evaluation of the individual sample data is extremely important. A database will be generated from the validated and qualified Form I's. Before beginning the individual Sample Checklists in DVS, pull all the Form I's for the

shift you are going to evaluate from the QC Summary package and organize them in the order of date and time of analysis. On the lower left corner of each Form I, write the correct extraction date. Take the extraction date from the Form II; however, if the extraction date does not appear to be correct, check the extraction logbook. As you evaluate the sample data, you will need the Form I's available. Evaluate the following items for each sample within a shift.

a) Verify that the laboratory name, lab analysis ID, sample ID, shift file name, instrument, and calibration date on the DVS checklist are correct.

b) Compare the sample tracking information on the DVS checklist with the information on the Form I. If the information is not identical in both locations, a resubmission of either the Form I or the DVS floppy diskette for that shift is necessary. If you are unsure of what is needed, contact either the task leader or the software contractor. A discrepancy in the login date can be verified against the chain-of-custody forms, the percent moisture, extraction analyst, and weight of sample against the extraction log, and date of analysis against the instrument run log. If the concentration/dilution factor is not 1.0, verify the dilution against the screening data and the instrument run log.

c) The Sample Checklist - Error Listing summarizes the QA deficiencies detected by the DVS for the sample. The deficiencies listed will include all items exceeding the QA criteria listed in the Summary of QA Criteria at the end of this SOP. Verify all of the items listed. If the raw data indicates that the comment is incorrect, contact the software contractor.

d) Check the surrogate recoveries against the raw data and quantitation report. Spot check the calculations and compare to the results on Form II. If the recoveries are not within criteria, make a comment on the checklist and flag the data accordingly. Read the reextraction and reanalysis requirements in Exhibit C of the SOW. If a surrogate is out of criteria, the sample needs reextraction. If after reextraction, the criteria still are not met, both results get entered into the Form I Database. Keep track of this type of occurance so that only the appropriate Form I's get into the final database.

e) Check the internal standard retention time and area difference criteria against the raw data. The data on Form X's must be consistent with the raw data. If there is a discrepancy, make a comment and determine if a resubmission is necessary. Are all QA criteria met? If not, make a comment on the checklist and qualify the data accordingly. Again, as with surrogates, internal standards have rigid reanalysis requirements. See the SOW, Exhibit C. Care must be taken to evaluate which Form I's get entered into the database.

f) Review the raw data and quantitation report to see if the LCICs reported meet all of the identification criteria (scan range, ion ratio, all ions present). Also determine if all low level peaks, greater than 0.2 ppb equivalent concentration, are reported. Did the laboratory use the appropriate flags on the Form I?

g) Spot check the calculations to determine if the appropriate RRF, sample weight, percent moisture were used for quantitation. If manual quantitation was used, was it necessary?

h) It is imperative that all the information on the Form I correspond with the raw data. Check everything carefully!!

After all the data has been reviewed, print out the DVS Checklist Incomplete Reports for Initial Calibration, Shift Results, and Samples (see illustrations 11-13). If any checklists are incomplete, complete the record. If there is no raw data for the missing sample(s) or there is any other discrepancy, try to resolve it. Request any necessary resubmissions or qualify the data accordingly.

10. SCREENING DATA - The screening data must be reviewed to determine if the laboratory diluted the sample to get the analyte at the highest concentration in the upper half of the calibration range. Also, if a sample was screened, this should be indicated on the Form I for that sample.

11. SILICA GEL VERIFICATION DATA - Compare the raw data for the silica gel verification with the results reported on the Form XI. If a batch of silica did not meet the QC criteria check to see if it was used for the purification of the sample extracts.

12. DELIVERABLES - The SOW requires that the data package include a long list of items that need to be checked to see if they are present and reviewed only as needed. These items are listed in the SOW, Exhibit D, Table D-3. Please check to see if everything on the list was received. If not, request the appropriate resubmissions.

13. FORM I REVIEW - When the data evaluator completes the data validation and has put all the qualifiers on the Form I, put the Forms in order of date and time. Also put the Data Validation Checklists in sequential order. This package is then given to the final data reviewer who will qualify each analyte on every Form I with a G, U, B, or X (see illustration 14). See the Data Qualifier List. The data reviewer will return the package with questions and comments. Review these questions and comments and make any revisions to the Form I qualifiers and DVS checklists. You are now finished!!!!

EXAMPLE OF LOGIN BOOK PAGE

FLOPPY DISC INFORMATION	NUMBER	DATE	LAB	PAGES	BOXES	COURIER	INITIALS
8 FLOPPY DISKETTES	1	12/16/87	LAB 1	5561	1 LARGE 1 SMALL	FED EX	CMS
5 FLOPPY DISKETTES	2	12/17/87	LAB 4	3844	1 LARGE	FED EX	DLB
6 FLOPPY DISKETTES	3	12/17/87	LAB 2	4487	1 LARGE	FED EX	CMS

Illustration 1

Date: 03/18/88
Time: 08:11:49

DATA VALIDATION SYSTEM
Summary Concentration Table

Page 2
Lab:

Concentrations by LCIC

Sample No.	1 DCB	2 TCB	3 QCB	4 CN	5 A-BHC	6 D-BHC	7 B-BHC	8 G-BHC	Analysis ID
HS0171	0.539	0.201	0.127	0.106	0.325	ND	0.153	ND	B710222-04
HS0182	1.018	0.299	0.140	0.093	0.096	ND	0.067	ND	B711011-05
HS0191	0.716	0.650	0.566	0.099	0.165	0.082	0.195	0.370	B711126-01T
HS0202	0.489	0.188	0.115	0.107	0.083	ND	0.051	0.328	B710164-05
HS0215	0.616	0.713	0.900	ND	0.261	0.105	0.346	0.068	B711068-08
HS0230	0.526	0.526	0.447	0.137	0.094	0.182	0.162	ND	B710177-07
HS0241	0.779	1.052	1.433	0.097	0.326	0.338	0.257	0.204	B711125-02
HS0244	0.762	0.853	1.119	ND	0.725	0.116	1.417	0.167	B711036-07AS
HS0245	0.549	0.425	0.792	0.140	0.092	0.108	2.831	0.172	B711014-03
HS0246	1.515	0.369	0.221	0.192	0.117	0.071	0.199	0.557	B711035-08
HS0247	0.878	0.382	0.262	0.115	0.151	ND	1.500	0.092	B711012-02
HS0258	0.621	0.280	0.325	0.126	0.114	0.055	0.080	ND	B711012-06AS
HS0267	1.060	6.932	10.910	0.179	7.192	2.089	13.250	1.868	B710222-08T
HS0275	0.817	0.683	0.457	0.153	0.145	ND	0.197	ND	B711068-01
HS0284	0.566	0.186	0.075	0.141	ND	ND	1.853	ND	B711014-05
HS0289	0.737	0.652	0.641	0.109	0.382	0.180	0.201	ND	B710152-05
HS0312	0.752	0.574	0.424	0.100	0.329	0.189	2.763	0.153	B710140-03
HS0315	0.625	0.366	0.336	0.145	0.058	ND	2.068	0.058	B711014-02
HS0320	0.741	0.881	0.554	0.119	1.700	1.546	0.483	0.711	B711012-09AS
HS0331	0.848	0.242	0.055	0.100	ND	0.067	ND	ND	B710140-08
HS0335	0.808	2.110	2.024	0.090	2.317	0.283	2.462	0.222	B710143-08
HS0337	1.142	0.405	0.395	0.102	0.131	0.063	0.254	0.125	B711036-02
HS0342	0.728	0.697	0.600	0.071	0.270	0.192	0.788	0.050	B710219-03
HS0350	0.910	0.385	0.216	0.142	0.080	ND	0.062	ND	B710290-04
HS0358	1.013	0.315	0.080	0.212	ND	0.152	4.994	0.071	B710140-01
HS0365	0.780	0.225	0.137	0.071	0.057	0.656	0.230	ND	B710290-06AS
HS0384	0.991	0.444	0.324	0.105	0.144	0.161	0.219	0.095	B710218-02AS
HS0385	0.872	0.300	0.214	0.084	0.156	0.092	0.198	ND	B711011-07
HS0399	0.711	0.230	0.171	0.108	ND	0.173	1.858	ND	B710140-02
HS0404	0.648	1.142	1.012	0.101	0.570	0.279	0.911	0.090	B711035-03S
HS0432	0.749	0.244	0.112	0.103	ND	0.298	0.166	0.086	B711124-05
HS0445	0.534	0.395	0.351	0.092	0.082	0.060	0.113	ND	B710154-09
HS0446	1.093	4.138	5.560	0.069	1.158	0.469	2.085	0.212	B710143-02S
HS0452	0.756	0.529	0.335	0.132	0.109	0.086	0.119	ND	B710152-04T
HS0467	0.555	3.351	4.717	0.093	5.261	0.281	2.343	0.476	B711125-06
HS0467	1.698	7.648	6.487	0.236	36.224	0.740	14.691	1.700	B711125-06A
HS0473	0.888	0.618	0.710	0.118	0.145	0.099	0.684	ND	B710290-05
HS0477	1.222	3.015	0.939	0.095	0.242	0.141	0.309	0.084	B710164-04
HS0480	1.031	0.355	0.216	0.118	0.100	0.468	0.163	0.067	B711011-06
HS0490	0.731	0.263	0.312	ND	0.090	ND	0.130	ND	B710143-06
HS0502	0.914	0.358	0.208	0.120	0.067	ND	1.241	ND	B711035-07
HS0503	2.217	13.841	18.838	0.189	153.527	5.824	101.722	20.993	B711014-06AS
HS0507	0.515	0.409	0.429	0.103	0.126	0.067	0.085	0.055	B711124-01A

Illustration 2

```
                                          DATA VALIDATION SYSTEM                                              Page   3
Date:  03/04/88                        Error Listing of Samples/Analyses                                      Lab:
Time:  09:41:43                              By Lab Sample ID
                                                                                Upper        Lower       Parameter
  Lab Analysis ID      Sample ID              Parameter Name                   Criteria     Criteria       Value
 ===================  ============  =========================================  ============ ============ ============
 LC09974R11           RMSHSA742     MS/MSD % REC FOR A-BHC OUTSIDE QC LIMIT        139.000       65.000       64.633
                                    MS/MSD % REC FOR B-BHC OUTSIDE QC LIMIT        106.000       64.000       63.101
                                    MS/MSD % REC FOR D-BHC OUTSIDE QC LIMIT        138.000       64.000       60.104
 LC09974R12           RMSDHSA742    % RECOVERY FOR 1,4-DBB OUTSIDE QA/QC LIMITS    104.000       51.000       46.068
                                    AREA RESPONSE FOR D8-NAPH OUT QC LIMIT          50.000      -60.000       57.000
                                    MS/MSD % REC FOR 1,2,3,4-DCB OUT QC LIMIT      113.000       62.000       59.050
                                    MS/MSD % REC FOR 2-CNP OUTSIDE QC LIMIT        114.000       43.000       27.977
                                    MS/MSD % REC FOR A-BHC OUTSIDE QC LIMIT        139.000       65.000       62.939
                                    MS/MSD % REC FOR B-BHC OUTSIDE QC LIMIT        106.000       64.000       47.008
                                    MS/MSD % REC FOR D-BHC OUTSIDE QC LIMIT        138.000       64.000       56.329
                                    MS/MSD % REC FOR G-BHC OUTSIDE QC LIMIT        119.000       66.000       65.494
                                    MSD RPD FOR 1,2-DCB OUTSIDE QC LIMIT            30.000        0.000       36.766
                                    MSD RPD FOR 2-CNP OUTSIDE QC LIMIT              30.000        0.000       30.854
 LC09976004           HS0710        % RECOVERY FOR 2,4,6-TBBP OUTSIDE QC LIMITS    126.000       56.000      130.503
 LC09976009           BLM1102       % RECOVERY FOR 2,4,6-TBBP OUTSIDE QC LIMITS    126.000       56.000      137.555
 LC09976010           QCEM7007      % RECOVERY FOR 2,4,6-TBBP OUTSIDE QC LIMITS    126.000       56.000      136.409
 LC09976R01           HS0540        AREA RESPONSE FOR D10-ACENAPH OUT QC LIMIT      50.000      -60.000       56.000
 LC09976R05           RHS0147       AREA RESPONSE FOR D10-ACENAPH OUT QC LIMIT      50.000      -60.000       64.000
                                    AREA RESPONSE FOR D8-NAPH OUT QC LIMIT          50.000      -60.000       60.000
 LC09976T01           RHS0540       AREA RESPONSE FOR D10-ACENAPH OUT QC LIMIT      50.000      -60.000       62.000
 LC10005008           HS0555        AREA RESPONSE FOR D10-ACENAPH OUT QC LIMIT      50.000      -60.000       54.000
 LC10005R06           RHS0555       AREA RESPONSE FOR D10-ACENAPH OUT QC LIMIT      50.000      -60.000       96.000
```

Illustration 3

Date: 03/04/88
Time: 09:37:27

DATA VALIDATION SYSTEM
Error Listing of Samples/Analyses
By Error Type

Page 1
Lab:

Parameter Name	Analysis ID	Sample ID	Upper Criteria	Lower Criteria	Parameter Value
% RECOVERY FOR 1,2,4,5-QBB OUTSIDE QC LIMIT	BLR113087	BLR1130	115.000	50.000	0.000
	INSTBLK1025	BLR1025	115.000	50.000	0.000
	LC09949R09	HS1371	115.000	50.000	0.000
	LC10020R07	HS0808	115.000	50.000	0.000
	LC10122R03	HS0773	115.000	50.000	0.000
% RECOVERY FOR 1,4-DBB OUTSIDE QA/QC LIMITS	BLR113087	BLR1130	104.000	51.000	0.000
	INSTBLK1025	BLR1025	104.000	51.000	0.000
	LC09949R11	BLMR1026	104.000	51.000	107.791
	LC09949R14	QCEMR7014	104.000	51.000	105.43
	LC09957R04	HS0471	104.000	51.000	50.303
	LC09957R04	HS0471	104.000	51.000	50.303
	LC09974002	HS0742	104.000	51.000	48.631
	LC09974011	MSHS0742	104.000	51.000	48.706
	LC09974012	MSDHS0742	104.000	51.000	46.109
	LC09974R02	RHSA742	104.000	51.000	47.482
	LC09974R11	RMSHSA742	104.000	51.000	50.286
	LC09974R12	RMSDHSA742	104.000	51.000	46.068
	LC1002003	HS0006	104.000	51.000	47.374
% RECOVERY FOR 2,4,6-TBBP OUTSIDE QC LIMITS	BLR113087	BLR1130	126.000	56.000	0.000
	INSTBLK1025	BLR1025	126.000	56.000	0.000
	LC09966000	BLM1019	126.000	56.000	140.733
	LC09973002	HS0508	126.000	56.000	138.834
	LC09973002	HS0508	126.000	56.000	138.834
	LC09973003	HS0800	126.000	56.000	167.556
	LC09973003	HS0800	126.000	56.000	167.556
	LC09973004	HS0038	126.000	56.000	163.174
	LC09973004	HS0038	126.000	56.000	163.174
	LC09973008	HS0173	126.000	56.000	146.402
	LC09973008	HS0173	126.000	56.000	148.402
	LC09973010	BLM1028	126.000	56.000	129.532
	LC09973010	BLM1028	126.000	56.000	129.532
	LC09976004	HS0710	126.000	56.000	130.503
	LC09976009	BLM1102	126.000	56.000	137.555
	LC09976010	QCEM7007	126.000	56.000	136.409
	LC1002011	BLM1111	126.000	56.000	129.642
	LC1002012	QCEM7013	126.000	56.000	130.092
	LC10071010	QCEM7016	126.000	56.000	131.234
	LC10110010	QCEM7022	126.000	56.000	126.722
AREA RESPONSE FOR D10-ACENAPH OUT QC LIMIT	LC09974002	HS0742	50.000	-60.000	179.000
	LC09974003	HS0103	50.000	-60.000	210.000
	LC09974011	MSHS0742	50.000	-60.000	279.000
	LC09974012	MSDHS0742	50.000	-60.000	112.000
	LC09974R03	RHS0103	50.000	-60.000	222.000
	LC09974R07	RHS1302	50.000	-60.000	54.000

Illustration 4

Date: 03/18/88
Time: 07:38:13

DATA VALIDATION SYSTEM
Audit Trail for Lab Database

Page 1
Lab:

Initial Calibration ID	Shift Results ID	Analysis ID	Sample ID	Log-in Date	Final Package Date	Final Package Time	Checklist Completed
IHP5970 102287				/ /	03/16/88	18:34	
	QS171025.			/ /	03/16/88	18:11	
		8709189-01	QCEM8002	09/18/87	03/16/88	18:11	
		8710140-01	HS0358	10/16/87	03/16/88	18:11	
		8710140-02	HS0399	10/16/87	03/16/88	18:11	
		8710140-03	HS0312	10/16/87	03/16/88	18:11	
		8710140-08	HS0331	10/16/87	03/16/88	18:11	
		8710140-11A	BLM101687A	10/16/87	03/16/88	18:11	
	QS871022.			/ /	03/16/88	18:11	
	QS871029.			/ /	03/16/88	18:11	
		8709189-02	QCEM8003	09/18/87	03/16/88	18:11	
		8710143-03	HS0725	10/23/87	03/16/88	18:11	
		8710143-05	HS0603	10/16/87	03/16/88	18:11	
		8710143-06	HS0490	10/16/87	03/16/88	18:11	
		8710143-09	BLM101687C	10/16/87	03/16/88	18:11	
		8710152-01	HS0818	10/19/87	03/16/88	18:11	
		8710152-01-MS	MSHS0818	10/19/87	03/16/88	18:11	
		8710152-01-MSD	MSDHS0818	10/19/87	03/16/88	18:11	
		8710152-02	HS0151	10/19/87	03/16/88	18:11	
		8710152-06	HS0748	10/23/87	03/16/88	18:11	
		8710152-07A	HS0707	10/19/87	03/16/88	18:11	
		8710152-08A	HS1364	10/19/87	03/16/88	18:11	
	QS871030.			/ /	03/16/88	18:11	
		8709189-03	QCEM8004	10/31/87	03/16/88	18:11	
		8710154-04	HS0080	10/19/87	03/16/88	18:11	
		8710154-05	HS0726	10/19/87	03/16/88	18:11	
		8710154-09	HS0445	10/19/87	03/16/88	18:11	
		8710154-12	BLM101987C	10/19/87	03/16/88	18:11	
		8710164-02B	MSHS0659	10/20/87	03/16/88	18:11	
		8710164-02C	MSDHS0659	10/20/87	03/16/88	18:11	
		8710164-03	HS0511	10/20/87	03/16/88	18:11	
	QS871101.			/ /	03/16/88	18:11	
		8709189-12	QCEM8016	10/21/87	03/16/88	18:11	
		8710164-04	HS0477	10/20/87	03/16/88	18:11	
		8710164-06	HS0682	10/20/87	03/16/88	18:11	
		8710164-07	HS0732	10/20/87	03/16/88	18:11	
		8710164-08	HS1323	10/20/87	03/16/88	18:11	
		8710164-10	HS0527	10/20/87	03/16/88	18:11	
		8710164-11B	BLM1020A	10/20/87	03/16/88	18:11	
		8710177-01A	HS0660	10/21/87	03/16/88	18:11	
		8710177-01B	MSHS0660	10/21/87	03/16/88	18:11	
		8710177-01C	MSDHS0660	10/21/87	03/16/88	18:11	
		8710177-03	HS0858	10/21/87	03/16/88	18:11	
		8710177-05	HS0092	10/21/87	03/16/88	18:11	

Illustration 5

```
03/21/88                LOVE CANAL SOFTWARE SUPPORT                 Page 1
                        Initial Calibration Checklist
LAB:            INSTRUMENT: IHP5970           CALIBRATION DATE:  10/22/87
--------------------------------------------------------------------------

1.  Initial Calibration

        Percent RSD exceptions checked.

        Check quantitation reports for evidence of editing.

        Examine chromatograms for interference. peak shape. and reasonableness.

        Miscellaneous.

     Comments:



--------------------------------------------------------------------------
                 Initial Calibration Checklist - Error Listing
--------------------------------------------------------------------------

                                              Parameter   Upper       Lower
               Parameter  Name                  Value     Criteria    Criteria
               ===============               =========== =========== ===========

NO ERROR RECORDS FOUND
```

Page 1

03/21/88

LOVE CANAL SOFTWARE SUPPORT

Shift Results Checklist

INSTRUMENT: IHP5970
CALIBRATION DATE: 10/22/87

LAB:

SHIFT: QS171025

---

1. Deliverables Check

Are all deliverables present?
If not. enter missing deliverables below:

Missing	Date Resolved

2. Performance Check 1 (PC1) Date: Time:

Is this a PC2 midpoint for a 16 hour analytical run? (Y/N)
If yes. please enter first-half shift result file name:
Compare percent valley SICPS to see if agrees with reported values.
Compare reported signal to noise ratios with raw data.
Check ion ratio criteria
Check chromatography.
Check quantitation reports for evidence of editing.
Miscellaneous.
Comments:

3. Continuing Calibration (CC) Date: Time:

Internal standard areas.
Check retention time differences.
Miscellaneous.
Comments:

4. Performance Check 2 (PC2) Date: Time:

Compare percent valley SICPS with reported values.
Compare reported signal to noise ratios with raw data.
Check ion ratio criteria
Check chromatography.
Check quantitation reports for evidence of editing.
Miscellaneous.
Comments:

Illustration 7

03/21/88 LOVE CANAL SOFTWARE SUPPORT Page 2

Shift Results Checklist

INSTRUMENT: IHP5970
CALIBRATION DATE: 10/22/87
LAB: SHIFT: 0S171025

---

5. Blind QC Samples Sample ID:

Recoveries within acceptance criteria.
Check chromatography.
Check quantitation reports.
Miscellaneous.
Comments:

6. EPA Check Standard (EMPC) Sample ID:

Recoveries within acceptance windows and exceptions.
Check chromatography.
Check quantitation reports.
Miscellaneous.
Comments:

7. Method/Holding Blanks Sample ID:

Check each SICP for interferences. Make sure SICP is displayed on a scale to show contamination at the appropriate level.
Check that data is flagged if blank is contaminated and appropriate action is taken.
Compare report form with chromatogram.
Miscellaneous.
Comments:

8. MS/MSD Sample ID

Examine raw data for problems and discrepancies.
Outside criteria - see narrative for further discussion.
Examine SICPS and quantitation reports.
Miscellaneous.
Comments:

```
                                                                    Page 3
03/21/88                  LOVE CANAL SOFTWARE SUPPORT

                     Shift Results Checklist - Error Listing
                                                   INSTRUMENT: IHP5970
LAB:                 SHIFT: OS171025         CALIBRATION DATE: 10/22/87
------------------------------------------------------------------------

                                             Parameter   Upper     Lower
                Parameter  Name                Value    Criteria  Criteria
                ===============            ========== ========== ==========

NO ERROR RECORDS FOUND
```

Illustration 7 cont.

03/21/88

LOVE CANAL SOFTWARE SUPPORT

Analysis Information

LAB:

LAB ANALYSIS ID: 8709189-01

SAMPLE: QCEM8002

SHIFT: 0S171025.

INSTRUMENT: IHP5970

CALIBRATION DATE: 10/22/87

---

1. Sample Tracking Dates:

Logged In: 09/18/87 Extraction: 10/21/87 Analysis: 10/25/87

Final Package: 03/16/88 Final Package Time: 18:11

2. Sample Data:

Weight of Aliquot Extracted grams: 20.00

Percent Moisture: 0.0

Concentration Dilution Factor: 1.000

3. Other Sample Information:

Sample ID of blank created for this sample: 8710140-11

Extraction Analyst:

Sulfur cleanup performed:

Process for screening high concentrations:

Illustration 8

Sample Checklist

LAB: LAB ANALYSIS ID: 8709189-01 SAMPLE: QCEMB002

SHIFT: QS171025. INSTRUMENT: IHP5970 CALIBRATION DATE: 10/22/87

---

1. Surrogates

Check raw data to see if surrogates spiked into all samples.
Recoveries within criteria.
Miscellaneous.
Comments:

2. Internal Standards

RT Criteria. Area Criteria. Miscellaneous.
Comments:

3. Identification

All ions maximize simultaneously.
Appropriate flags used.
All peaks reported that meet identification criteria.
Low level peaks examined.
Miscellaneous.
Comments:

4. Quantitation

Appropriate RRF's used if nonstandard quantitation used.
Check integration parameters if manual quantitation used.
Miscellaneous.
Comments:

5. General

Review case narrative and address all problems.
Examine SICPS.
Examine quantitation reports.
Miscellaneous.
Comments:

Illustration 8 cont.

```
03/21/88                 LOVE CANAL SOFTWARE SUPPORT                  Page 3
                        Sample Checklist - Data Qualifiers
LAB:           LAB ANALYSIS ID: 8709189-01                 SAMPLE: QCEMB002
SHIFT: QS171025          INSTRUMENT: IHP5970         CALIBRATION DATE: 10/22/87
-------------------------------------------------------------------------------
                                                1     2     3     4     5

  SAMPLE SPECIFIC FLAGS
  ANALYTE SPECIFIC FLAGS:
  ----------------------
     1.2-Dichlorobenzene
     1.2.4-Trichlorobenzene
     1.2.3.4-Tetrachlorobenzene
     2-Chrolonaphthalene
     Alpha-BHC
     Delta-BHC
     Beta-BHC
     Gamma-BHC
-------------------------------------------------------------------------------
                        Sample Checklist - Error Listing
-------------------------------------------------------------------------------
                                              Parameter     Upper       Lower
              Parameter  Name                   Value      Criteria    Criteria
              ===============              =========== =========== ===========

NO ERROR RECORDS FOUND
```

Illustration 8 cont.

LEMSCO RECORD OF TELEPHONE CONVERSATION

Date ____________ Region No. ____________

Recorded by ____________ Facility ____________

Talked with ____________ of ____________

Nature of call ___Incoming ___Outgoing

Route to the following:

Information only	Action
LOVE CANAL PHONE LOG	

Main subject of the call ____________

Items discussed ____________

Illustration 9

SUMMARY OF QA CRITERIA

INITIAL CALIBRATION DATA (FORM VIa):

Maximum %RSD = 30%, Delta-BHC = 35%

EPA CHECK STANDARD SUMMARY (FORM VIb):

QC Limits 80 - 120% recovery, Delta-BHC 70 -120% recovery

CONTINUING CALIBRATION CHECK (FORM VII):

Maximum %D = 25%, Delta-BHC = 30%

PERFORMANCE CHECK SOLUTION SUMMARY (FORM V):

PC1

Beta-BHC and Gamma-BHC baseline resolved: .... Y
% Valley (Chloronaphthalenes): .... < 30%
S/N Ratio (Beta-BHC m/z 217): .... > 2.5
S/N Ratio (1,2,4,5-Tetrachlorobenzene m/z 234): .... > 2.5

PC2

Beta-BHC and Gamma-BHC % valley: .... < 15%
% Valley (Chloronaphthalenes): .... < 50%
S/N Ratio (Beta-BHC m/z 217): .... > 2.5
S/N Ratio (1,2,4,5-Tetrachlorobenzene m/z 234): .... > 2.5

RATIOS

148/146	1,2-Dichlorobenzene:	0.52 - 0.78
182/180	1,2,4-Trichlorobenzene:	0.78 - 1.17
164/162	2-Chloronaphthalene:	0.26 - 0.39
216/214	1,2,3,4-Tetrachlorobenzene:	1.04 - 1.56
219/217	Alpha-BHC:	1.04 - 1.56
219/217	Beta-BHC:	1.04 - 1.56
219/217	Gamma-BHC:	1.04 - 1.56
219/217	Delta-BHC:	1.04 - 1.56
213/212	D10-Pyrene:	0.14 - 0.23

SOIL SURROGATE PERCENT RECOVERY (FORM II):

1,4-Dibromobenzene: .... 51 - 104
1,2,4,5-Tetrabromobenzene: .... 50 - 115
2,4,6-Tribromobiphenyl: .... 56 - 126

MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY SUMMARY (FORM III):

Compound	RPD Limit	Recovery Limit (Advisory)
1,2-Dichlorobenzene	30	39 - 105
1,2,4-Trichlorobenzene	30	42 - 106
2-Chloronaphthalene	30	43 - 114
1,2,3,4-Tetrachlorobenzene	30	62 - 113
Alpha-BHC	30	65 - 139
Beta-BHC	30	64 - 106
Gamma-BHC	30	66 - 119
Delta-BHC	30	64 - 138

BLANK SUMMARY (FORM IV):

QC Limit < 0.50 ppb, < 0.60ppb for 1,2-Dichlorobenzene

INTERNAL STANDARD RESPONSE AND RETENTION TIME VERIFICATION DATA SHEET (FORM X-I TO X-V):

D4-1,4-Dichlorobenzene, D8-Naphthalene, D10-Acenaphthene:
    RT Limit: +/- 10 seconds
    Area Response: -60% to +50%
D10-Phenanthrene, D10-Pyrene:
    RT Limit: +/- 10 seconds
    Area Response: -60% to +100%

```
Date:  03/18/88             DATA VALIDATION SYSTEM                  Page    1
Time:  07:47:02      Initial Calibration Checklist Incomplete      Lab:

                  Package Date            Initial Calibration ID
                  ============            ======================

                    03/16/88                  IHP5970    102287
                    03/16/88                  IHP5970    112087
                    03/16/88                  IHP5970    120387
```

```
Date:  03/18/88              DATA VALIDATION SYSTEM                  Page    1
Time:  07:48:17        Shift Results Checklist Incomplete           Lab:

        Package Date         Initial Calibration ID            Shift ID
        ============        ======================            ========
          03/16/88           IHP5970    102287                QS171025.
          03/16/88           IHP5970    120387                QS171203.
          03/16/88           IHP5970    102287                QS871022.
          03/16/88           IHP5970    102287                QS871029.
          03/16/88           IHP5970    102287                QS871030.
          03/16/88           IHP5970    102287                QS871101.
          03/16/88           IHP5970    102287                QS871104.
          03/16/88           IHP5970    102287                QS871111.
          03/16/88           IHP5970    102287                QS871114.
          03/16/88           IHP5970    102287                QS871116.
          03/16/88           IHP5970    102287                QS871118.
          03/16/88           IHP5970    112087                QS871119.
          03/16/88           IHP5970    112087                QS871120.
          03/16/88           IHP5970    112087                QS871125.
          03/16/88           IHP5970    112087                QS871129.
          03/16/88           IHP5970    112087                QS871130.
          03/16/88           IHP5970    112087                QS871201.
          03/16/88           IHP5970    112087                QS871202.
          03/16/88           IHP5970    120387                QS871203.
          03/16/88           IHP5970    120387                QS871209.
          03/16/88           IHP5970    120387                QS871216.
          03/16/88           IHP5970    120387                QS871217.
          03/16/88           IHP5970    120387                QS871218.
          03/16/88           IHP5970    120387                QS871220.
          03/16/88           IHP5970    120387                QS871221.
          03/16/88           IHP5970    120387                QS871222.
          03/16/88           IHP5970    120387                QS871223.
          03/16/88           IHP5970    120387                QS871228.
          03/16/88           IHP5970    120387                QS871229.
          03/16/88           IHP5970    120387                QS871230.
          03/16/88           IHP5970    120387                QS871231.
          03/16/88           IHP5970    120387                QS880107.
          03/16/88           IHP5970    102287                QS971118.
```

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best available copy.

Date: 03/18/88
Time: 07:55:11

DATA VALIDATION SYSTEM
Sample Checklist Incomplete

.Page 1
Lab:

Package Date	Initial Calibration ID		Shift ID	Lab Analysis ID
03/16/88	IHP5970	102287	QS171025.	8709189-01
03/16/88	IHP5970	102287	QS871029.	8709189-02
03/16/88	IHP5970	102287	QS871030.	8709189-03
03/16/88	IHP5970	120387	QS871223.	8709189-03R
03/16/88	IHP5970	102287	QS871111.	8709189-05
03/16/88	IHP5970	102287	QS871114.	8709189-06
03/16/88	IHP5970	102287	QS871118.	8709189-07
03/16/88	IHP5970	102287	QS871116.	8709189-08
03/16/88	IHP5970	112087	QS871120.	8709189-09
03/16/88	IHP5970	112087	QS871125.	8709189-11
03/16/88	IHP5970	102287	QS871101.	8709189-12
03/16/88	IHP5970	102287	QS171025.	8710140-01
03/16/89	IHP5970	102287	QS171025.	8710140-02
03/16/88	IHP5970	102287	QS171025.	8710140-03
03/16/88	IHP5970	120387	QS871222.	8710140-04AS
03/16/88	IHP5970	120387	QS871203.	8710140-05AS
03/16/88	IHP5970	120387	QS871223.	8710140-06S
03/16/88	IHP5970	120387	QS871203.	8710140-07AS
03/16/88	IHP5970	102287	QS171025.	8710140-08
03/16/88	IHP5970	120387	QS871216.	8710140-09R
03/16/88	IHP5970	102287	QS171025.	8710140-11A
03/16/88	IHP5970	120387	QS871216.	8710140-11RE
03/16/88	IHP5970	120387	QS871222.	8710140-12E
03/16/88	IHP5970	120387	QS871223.	8710143-02S
03/16/88	IHP5970	102287	QS871029.	8710143-03
03/16/88	IHP5970	102287	QS871111.	8710143-04
03/16/88	IHP5970	102287	QS871029.	8710143-05
03/16/88	IHP5970	102287	QS871029.	8710143-06
03/16/88	IHP5970	102287	QS871111.	8710143-07AS
03/16/88	IHP5970	102287	QS871111.	8710143-08
03/16/88	IHP5970	102287	QS871029.	8710143-09
03/16/88	IHP5970	102287	QS871111.	8710143-10BH
03/16/88	IHP5970	102287	QS871029.	8710152-01
03/16/88	IHP5970	102287	QS871029.	8710152-01-MS
03/16/88	IHP5970	102287	QS871029.	8710152-01-MSD
03/16/88	IHP5970	102287	QS871029.	8710152-02
03/16/88	IHP5970	120387	QS871230.	8710152-03DR
03/16/88	IHP5970	120387	QS871230.	8710152-03SRE
03/16/88	IHP5970	120387	QS871231.	8710152-04T
03/16/88	IHP5970	102287	QS871111.	8710152-05
03/16/88	IHP5970	102287	QS871029.	8710152-06
03/16/88	IHP5970	102287	QS871029.	8710152-07A
03/16/88	IHP5970	102287	QS871029.	8710152-08A

Illustration 13

12/23/87 17:20
FINAL
Version: 2.30

LCIC ANALYSIS DATA FORM
SEMI-VOLATILE LCIC

SAMPLE ID: HS0718

8 fk 2/5/88

cmS 1/25/88

LABORATORY: LAB

Lab Project No:	44358	Internal QC Report No:	-
Lab Login Id:	589945	Percent Moisture:	19.6
Screened:		Sulfur Cleanup:	
Analyst: TERMINAL		Weight Extracted:	20

	Date/Time Analyzed	Conc/Dil Factor	Shift Results File Name/ Data File Name
Semi-Volatile SIM:	12/17/87 18:33	1	QS121727.LAB >D1930::G6

Data Released/Authorized by: Laboratory Representative

Z8

PARAMETER (Semi-volatile)	CAS NUMBER	GC/MS SIM Conc. ug/kg	Data Qualifier	ID Criteria All Ions	Scan Range	Ion Ratio	RRT
1,2-Dichlorobenzene El u	000095-50-1	.39					
1,2,4-Trichlorobenzene G	000120-82-1	.41					
1,2,3,4-Tetrachlorobenzene G	000634-66-2	.39					
2-Chloronaphthalene G	000091-58-7	2.03					
Alpha-BHC G	000319-84-6	ND				•	
Delta-BHC G	000319-86-8	ND			•	•	
Beta-BHC G	000319-85-7	.12					
Gamma-BHC G	000058-89-9	ND				•	

COMMENTS:

XT 11/20/87

Form I

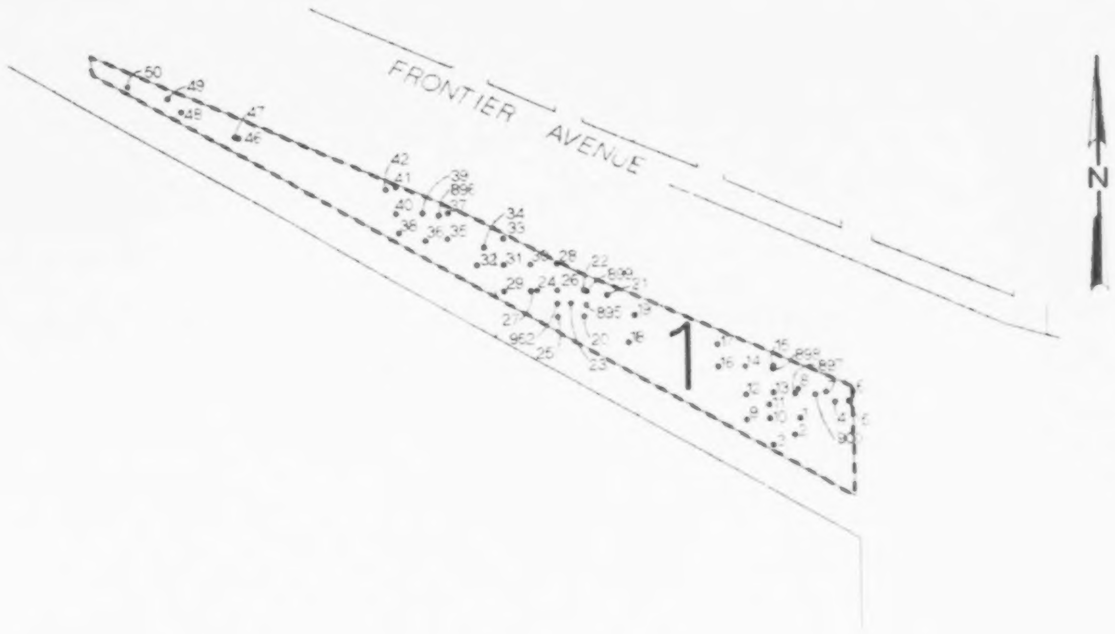
Appendix I
Supporting Information on Results of Sampling and Analytical Activities

Appendix I
SUPPORTING INFORMATION ON RESULTS OF SAMPLING AND ANALYTICAL ACTIVITIES

Figures I-1 through I-11 presented in this appendix show the locations of all samples collected for the LCIC study. Figures I-1 through I-7 show the location of the samples collected in the seven EDA sampling areas, and Figures I-8 through I-11 show the locations of the samples collected in Cheektowaga, Tonawanda, Census Tract 221, and Census Tract 225, respectively.

Table I-1 shows the analytical results of the LCICs analyzed for each of the sample locations shown on Figures I-1 through I-11. Table I-1 indicates the following:

- Seven samples were not collected.
- Eight samples could not be extruded.
- Ninety-eight samples could not be analyzed.
- Seventy-six contingency samples were collected.
- Some LCICs did not pass QC criteria.


FRONTIER AVENUE
N
1
50
49
48
47
46
42
41
40
39
896
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30
28
22
899
21
29
24
26
27
962
25
895
20
23
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5
900

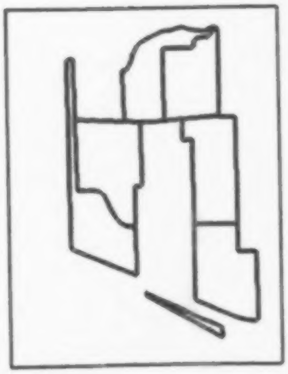


Figure I-1

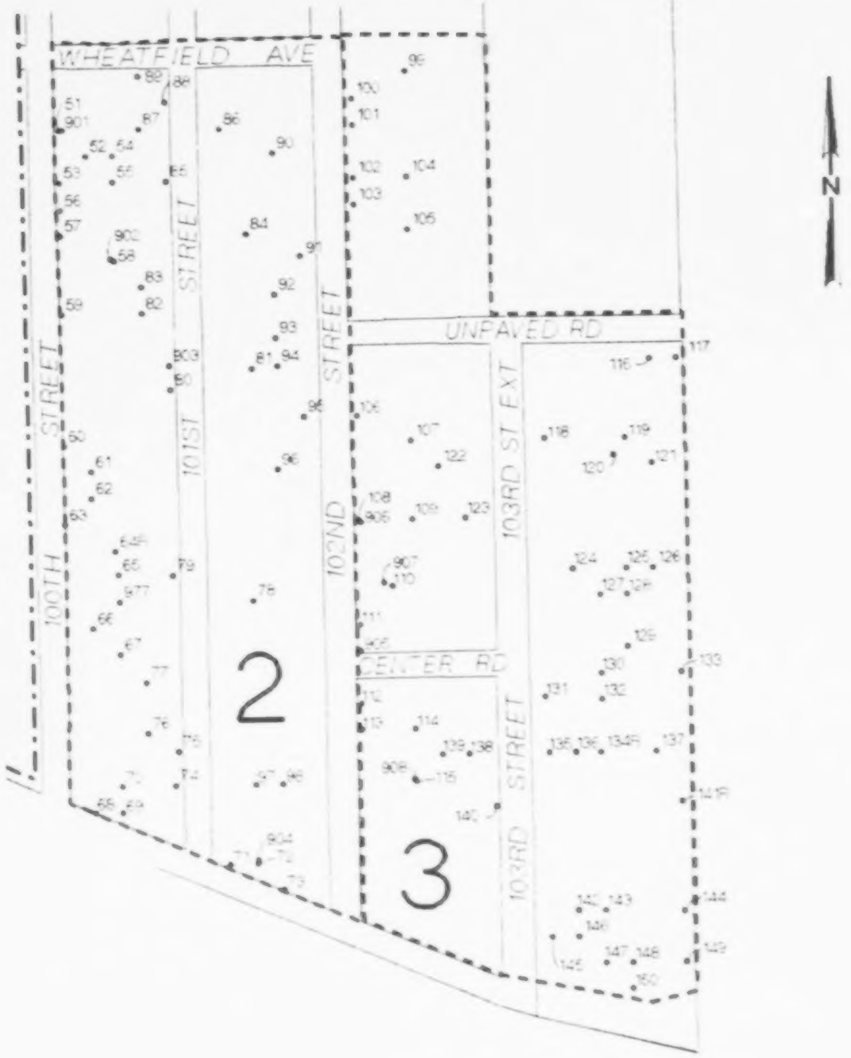
SOIL ASSESSMENT - INDICATOR CHEMICALS
SAMPLING AREA 1 OF THE EDA
LOCATION OF ACTUAL SAMPLING POINTS
SCALE: 1"=300'

LEGEND

- -- NEIGHBORHOOD BOUNDARY
- —· FENCE LINE AROUND LOVE CANAL REMEDIATION SITE
- 263 SITE NO.
- • SAMPLING POINT

SOURCE: EDA BOUNDARIES TAKEN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

263


WHEATFIELD AVE
100TH STREET
101ST STREET
102ND STREET
UNPAVED RD
103RD ST EXT
CENTER RD
103RD STREET
2
3
N
51
901
52
54
53
55
56
57
902
58
59
60
61
62
63
64R
65
977
66
67
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76
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141R
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150

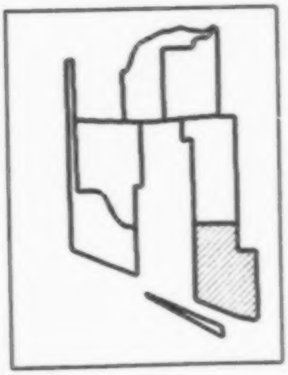

Figure I-2

SOIL ASSESSMENT - INDICATOR CHEMICALS
SAMPLING AREA 2 OF THE EDA
LOCATION OF ACTUAL SAMPLING POINTS
SCALE: 1"=300'

LEGEND

- – – NEIGHBORHOOD BOUNDARY
- —· FENCE LINE AROUND LOVE CANAL REMEDIATION SITE
- 263 SITE NO.
- • SAMPLING POINT

SOURCE: EDA BOUNDARIES TAKEN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

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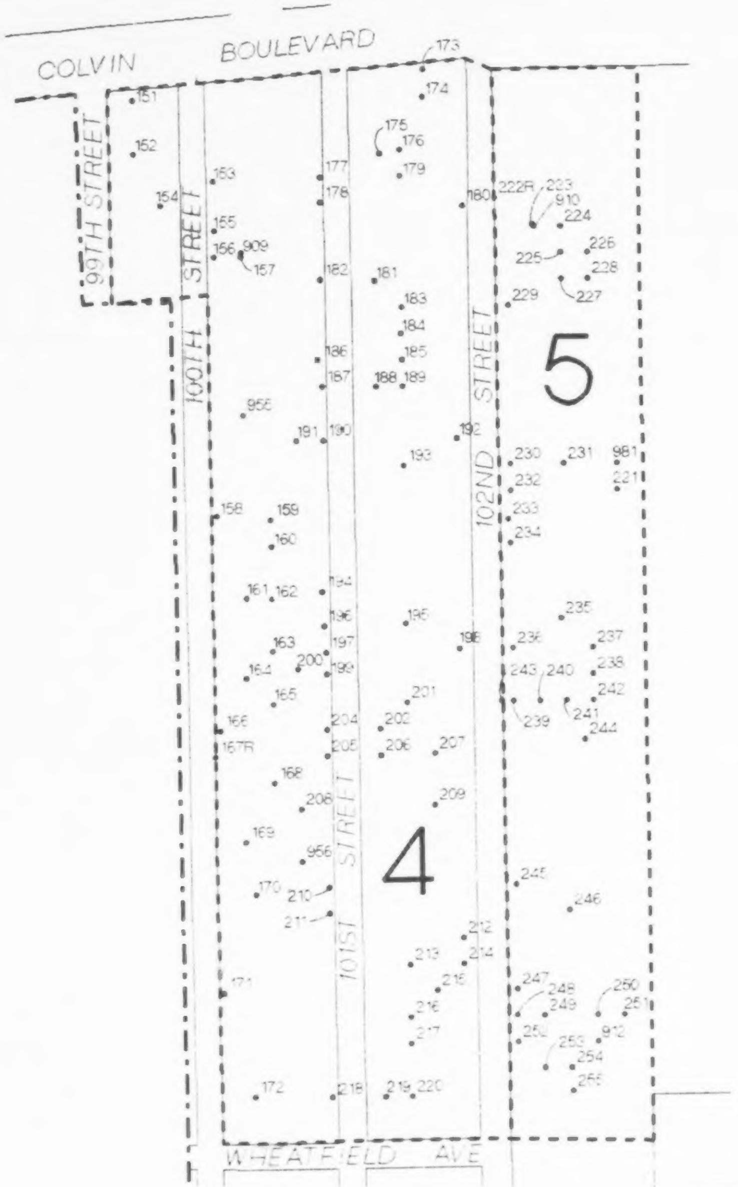

COLVIN BOULEVARD
99TH STREET
100TH STREET
101ST STREET
102ND STREET
WHEATFIELD AVE
4
5
N
151
152
153
154
155
156
909
157
173
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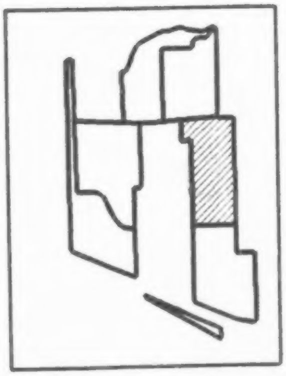


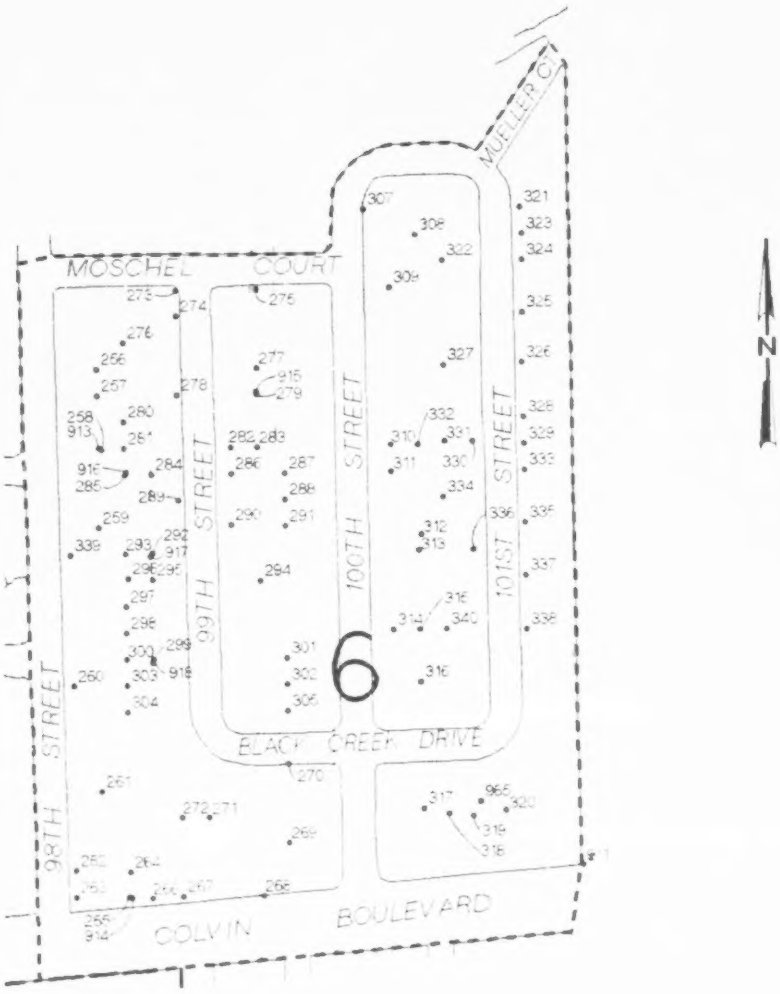
Figure I-3

SOIL ASSESSMENT - INDICATOR CHEMICALS
SAMPLING AREA 3 OF THE EDA
LOCATION OF ACTUAL SAMPLING POINTS
SCALE: 1"=300'

LEGEND

- - NEIGHBORHOOD BOUNDARY
— · FENCE LINE AROUND LOVE CANAL REMEDIATION SITE
255 SITE NO.
• SAMPLING POINT

SOURCE: EDA BOUNDARIES TAKEN FROM NEW YORK
STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702


MOSCHEL COURT
MUELLER CT
98TH STREET
99TH STREET
100TH STREET
101ST STREET
BLACK CREEK DRIVE
COLVIN BOULEVARD
N
6
273
274
275
276
256
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915
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278
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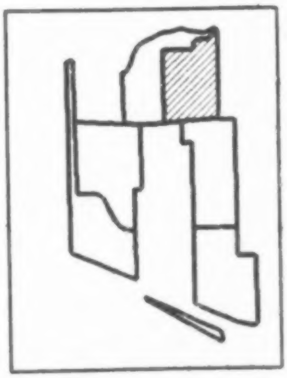


Figure I-4

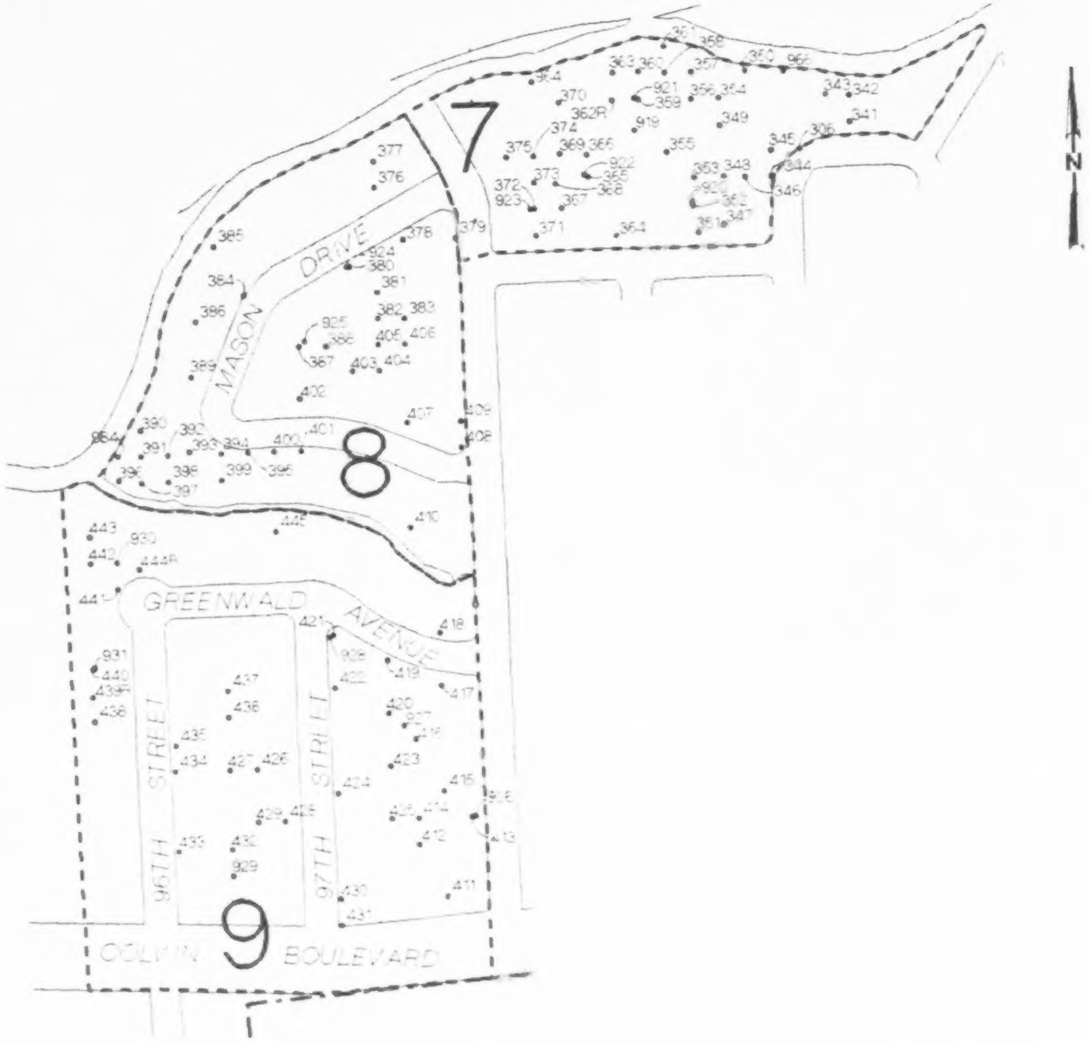
SOIL ASSESSMENT - INDICATOR CHEMICALS
SAMPLING AREA 4 OF THE EDA
LOCATION OF ACTUAL SAMPLING POINTS

SCALE: 1"=300'

LEGEND

- - NEIGHBORHOOD BOUNDARY
— · FENCE LINE AROUND LOVE CANAL REMEDIATION SITE
273 SITE NO.
• SAMPLING POINT

SOURCE: EDA BOUNDARIES TAKEN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702


7
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N
MASON DRIVE
GREENWALD AVENUE
96TH STREET
97TH STREET
COLVIN BOULEVARD
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434
435
436
437
438
439R
440
441
442
443
444R
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930
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964
965

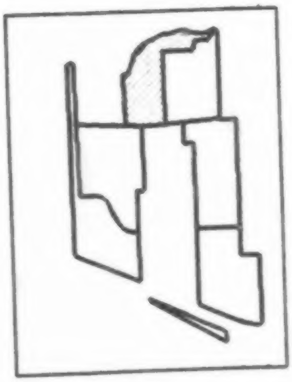

Figure I-5

SOIL ASSESSMENT - INDICATOR CHEMICALS
SAMPLING AREA 5 OF THE EDA
LOCATION OF ACTUAL SAMPLING POINTS
SCALE: 1"=300'

LEGEND

– –	NEIGHBORHOOD BOUNDARY
—·	FENCE LINE AROUND LOVE CANAL REMEDIATION SITE
263	SITE NO.
•	SAMPLING POINT

SOURCE: EDA BOUNDARIES TAKEN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

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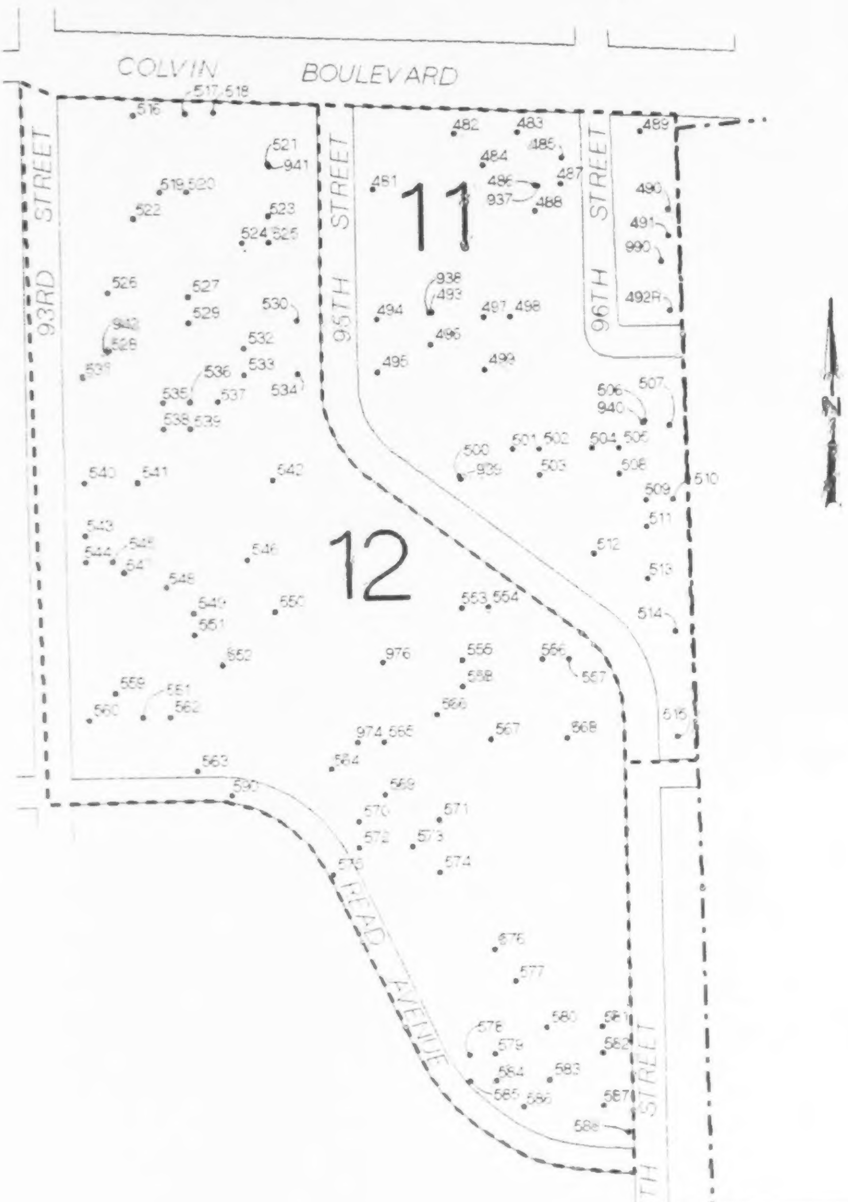
COLVIN BOULEVARD
93RD STREET
95TH STREET
96TH STREET
READ AVENUE
95TH STREET
11
12
N
516
517
518
521
941
519
520
522
523
524
525
526
527
529
530
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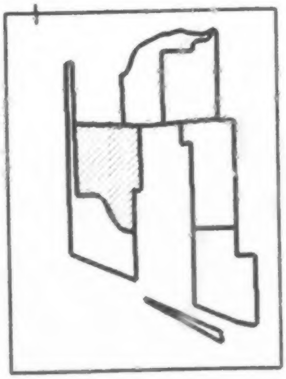


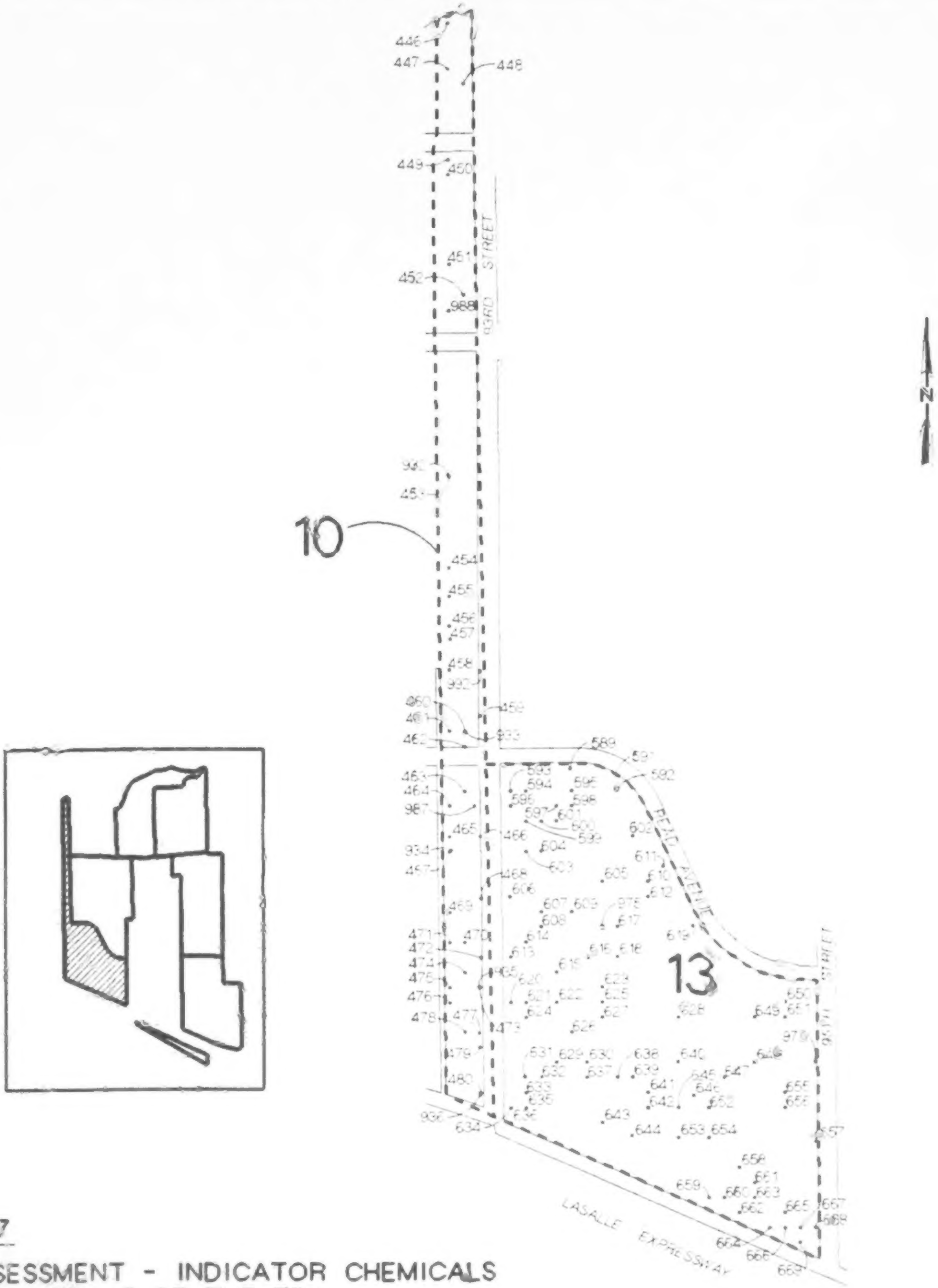
Figure I-6

SOIL ASSESSMENT - INDICATOR CHEMICALS
SAMPLING AREA 6 OF THE EDA
LOCATION OF ACTUAL SAMPLING POINTS
SCALE: 1"=300'

LEGEND

- - - NEIGHBORHOOD BOUNDARY
— · FENCE LINE AROUND LOVE CANAL REMEDIATION SITE
263 SITE NO.
• SAMPLING POINT

SOURCE: EDA BOUNDARIES TAKEN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702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95TH STREET
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LASALLE EXPRESSWAY

Figure I-7

SOIL ASSESSMENT - INDICATOR CHEMICALS
SAMPLING AREA 7 OF THE EDA
LOCATION OF ACTUAL SAMPLING POINTS
SCALE: 1"=500'

LEGEND

- - NEIGHBORHOOD BOUNDARY
— • FENCE LINE AROUND LOVE CANAL REMEDIATION SITE
263 SITE NO.
. SAMPLING POINT

SOURCE: EDA BOUNDARIES TAKEN FROM NEW YORK
STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

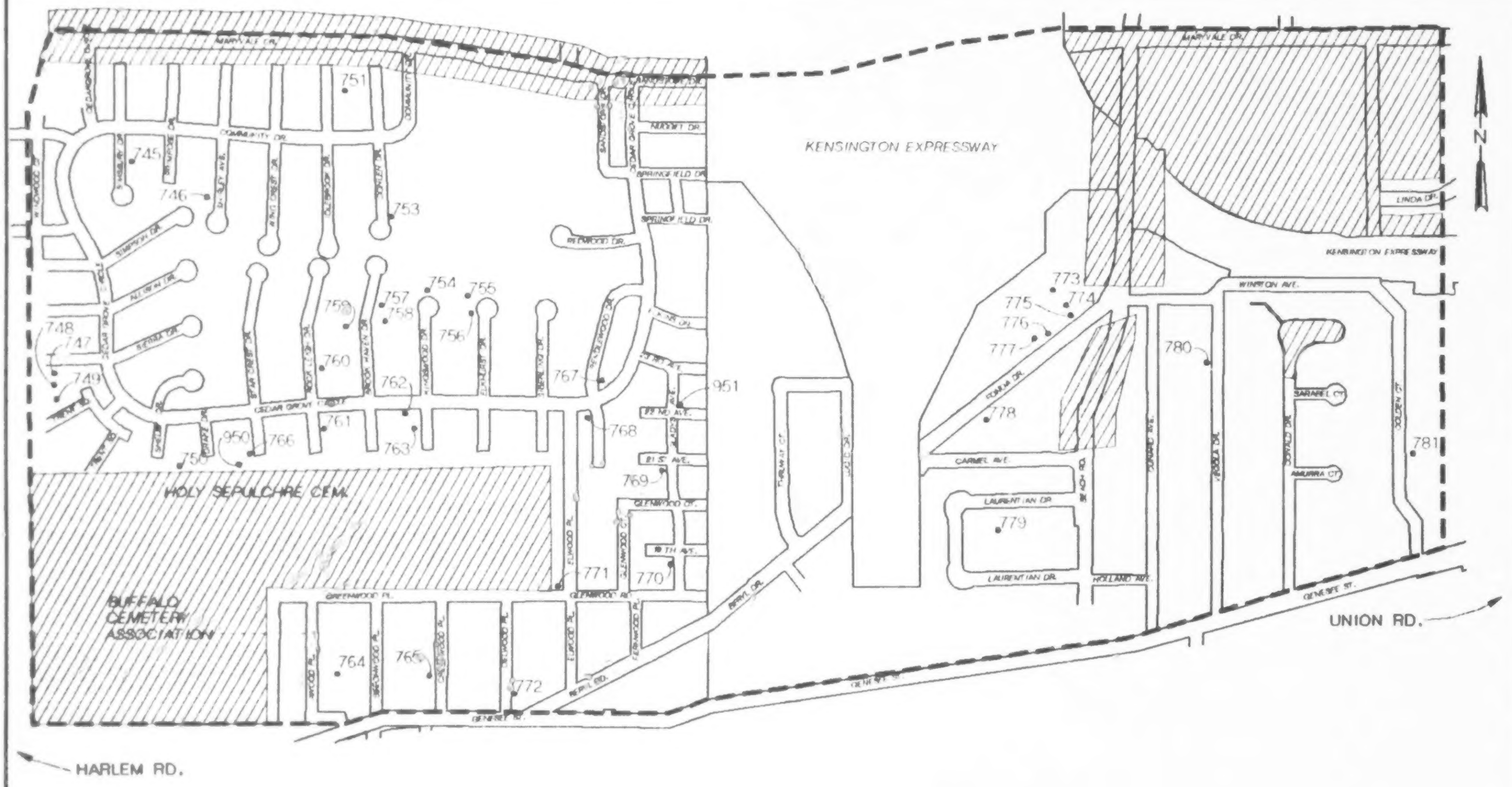
N
KENSINGTON EXPRESSWAY
HOLY SEPULCHRE CEM.
BUFFALO CEMETERY ASSOCIATION
HARLEM RD.
UNION RD.
MARYVALE DR.
COMMUNITY DR.
CEDAR GROVE CIRCLE
SPRINGFIELD DR.
REDWOOD DR.
CARMEL AVE.
LAURENTIAN DR.
HOLLAND AVE.
WINSTON AVE.
LINDA DR.
SARABEL CT.
AMURRA CT.
GOLDEN CT.
GENESEE ST.
GREENWOOD PL.
GLENWOOD RD.
ELMWOOD PL.
KENSINGTON EXPRESSWAY
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Figure I-8
SOIL ASSESSMENT--INDICATOR CHEMICALS
CHEEKTOWAGA COMPARISON AREA
LOCATION OF ACTUAL SAMPLING POINTS
SCALE: 1"=660'
SOURCE: MAP DRAWN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

LEGEND

- -	SAMPLING BOUNDARY
•	SAMPLING POINT
764	SITE NO.
▨	UNACCEPTABLE SAMPLE AREA

Reproduced from best available copy.

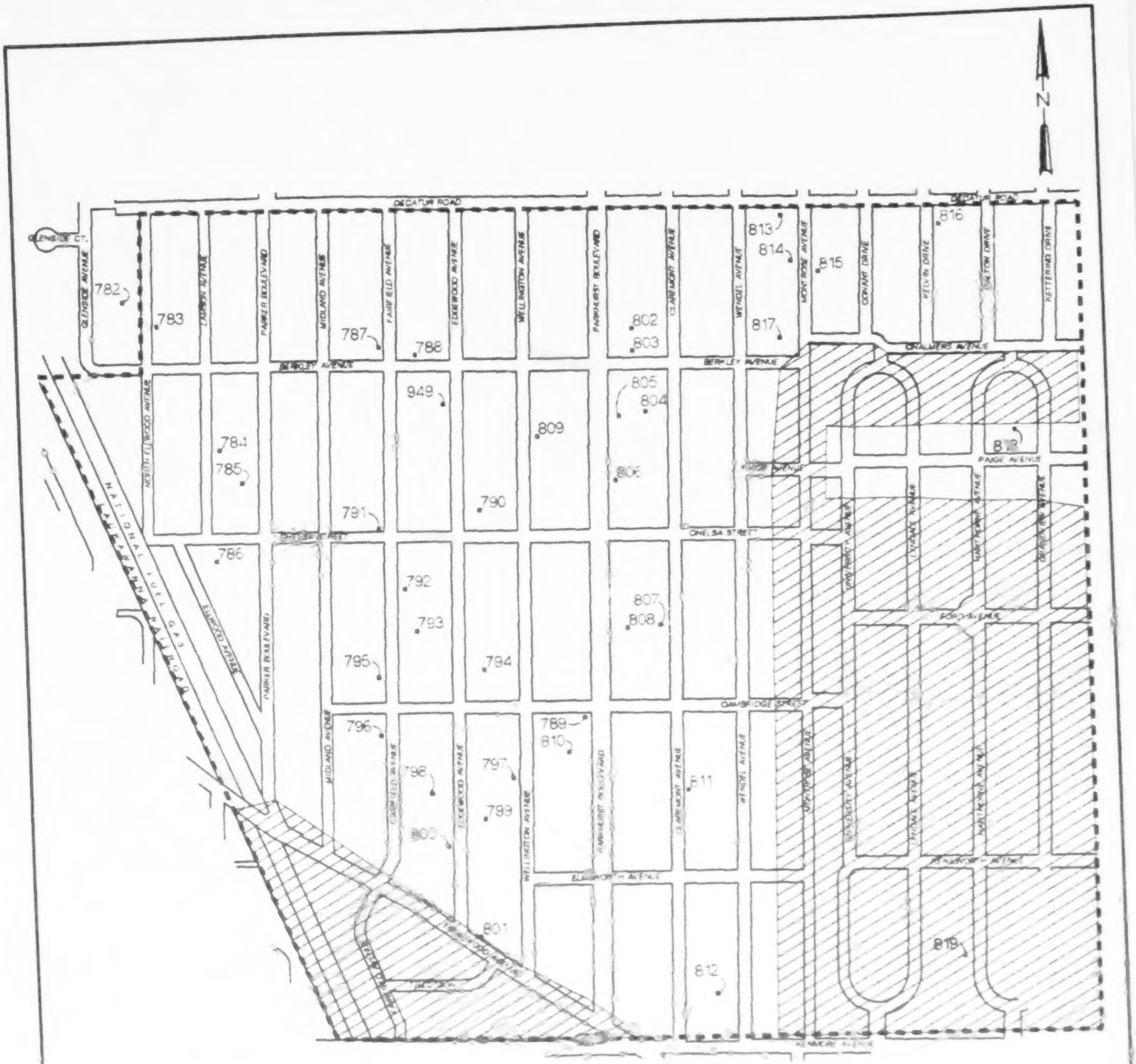
N
DECATUR ROAD
GLENSIDE CT.
GLENSIDE AVENUE
TAMPION AVENUE
PARKER BOULEVARD
MIDLAND AVENUE
FAIRFIELD AVENUE
EDGEWOOD AVENUE
WELLINGTON AVENUE
PARKHURST BOULEVARD
CLAREMONT AVENUE
WENDEL AVENUE
MONTROSE AVENUE
CONANT DRIVE
KELVIN DRIVE
DALTON DRIVE
KETTERING DRIVE
CHALMERS AVENUE
BERKLEY AVENUE
NORTH ELLWOOD AVENUE
PAIGE AVENUE
CHELSEA STREET
FORD AVENUE
CAMBRIDGE STREET
ELLSWORTH AVENUE
KENMORE AVENUE
NATIONAL FUEL GAS
RAILROAD
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Figure I-9

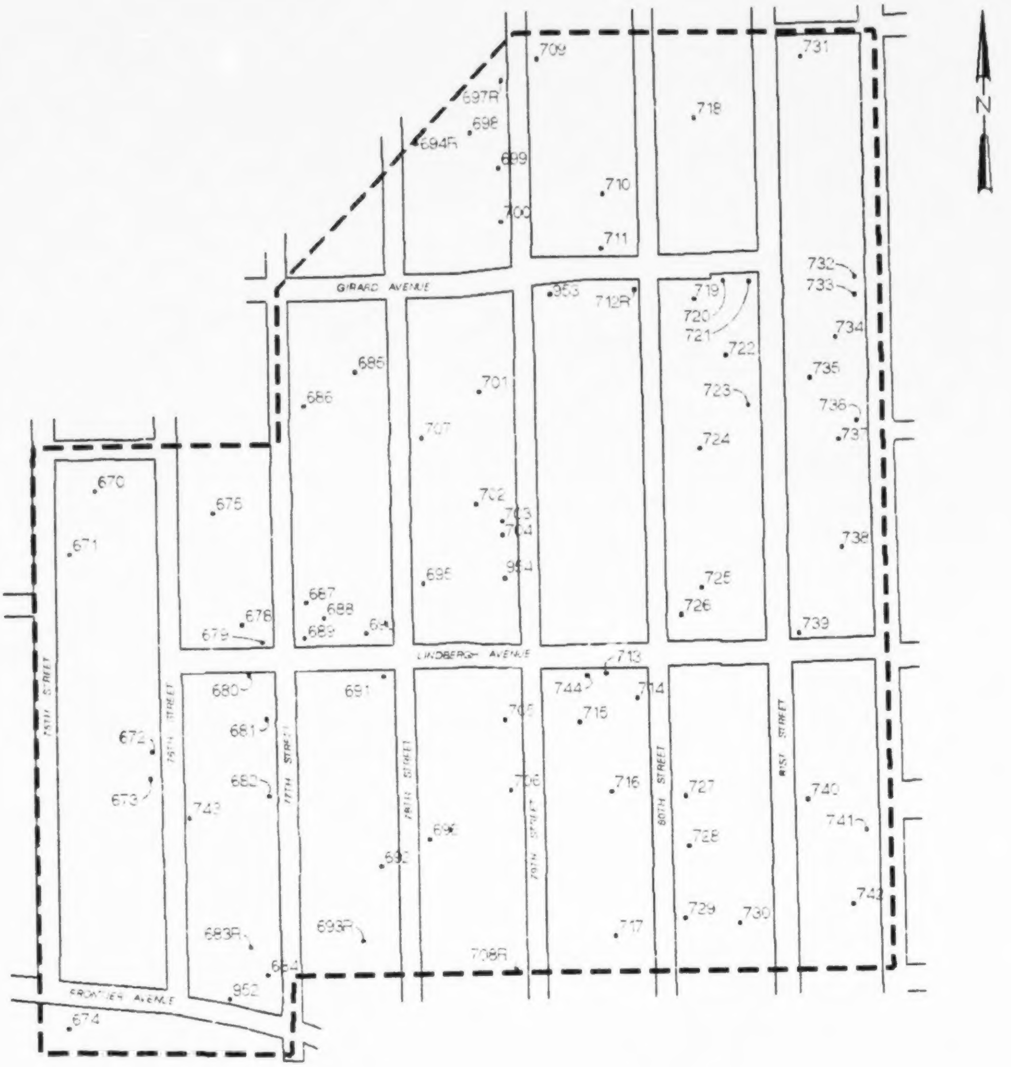
SOIL ASSESSMENT--INDICATOR CHEMICALS
TONAWANDA COMPARISON AREA (census tract no. 80.03)
LOCATION OF ACTUAL SAMPLING POINTS

SCALE: 1'=650

LEGEND

▬ ▬ ▬ SAMPLING BOUNDARY
• SAMPLING POINT
812 SITE NO.
▨ UNACCEPTABLE SAMPLE AREA

SOURCE: MAP DRAWN FROM NEW YORK
STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702


N
GIRARD AVENUE
LINDBERGH AVENUE
FRONTIER AVENUE
75TH STREET
76TH STREET
77TH STREET
78TH STREET
79TH STREET
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81ST STREET
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692
683R
693R
729
730
742
717
708R
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674

Figure I-10

SOIL ASSESSMENT--INDICATOR CHEMICALS
CENSUS TRACT 221 COMPARISON AREA
LOCATION OF ACTUAL SAMPLING POINTS

SCALE: 1"=400'

LEGEND

— — CENSUS TRACT 221 BOUNDARY
• SAMPLING POINT
674 SITE NO.

SOURCE: BOUNDARIES TAKEN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

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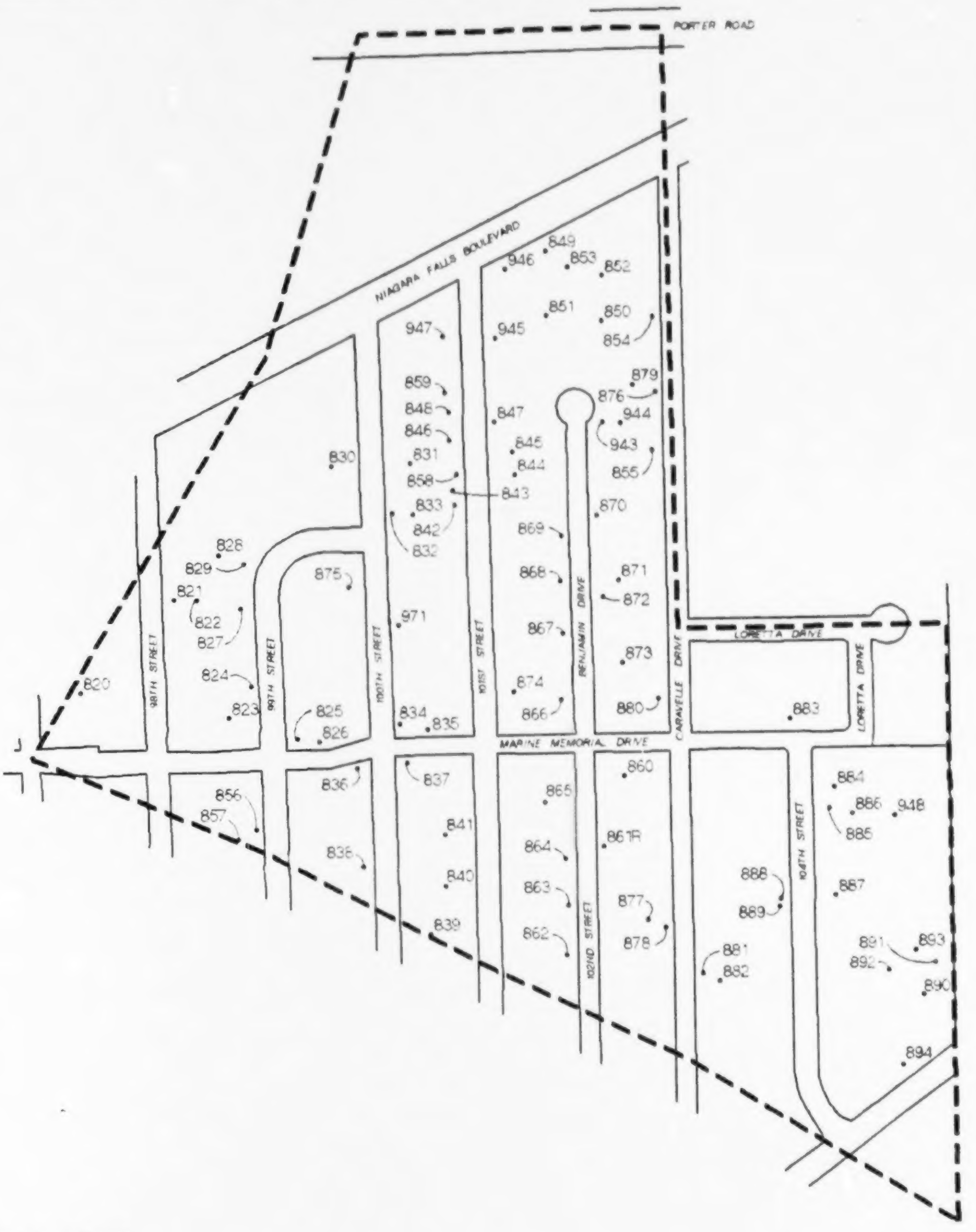
PORTER ROAD
N
NIAGARA FALLS BOULEVARD
98TH STREET
99TH STREET
100TH STREET
101ST STREET
BENJAMIN DRIVE
CARAVELLE DRIVE
LORETTA DRIVE
LORETTA DRIVE
MARINE MEMORIAL DRIVE
102ND STREET
104TH STREET
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Figure I-11

SOIL ASSESSMENT--INDICATOR CHEMICALS
CENSUS TRACT 225 COMPARISON AREA
LOCATION OF ACTUAL SAMPLING POINTS

SCALE: 1"=400'

LEGEND

— — CENSUS TRACT 225 BOUNDARY
• SAMPLING POINT
882 SITE NO.

SOURCE: BOUNDARIES TAKEN FROM NEW YORK STATE PROPERTY TAX LAW ARTICLE 17, SECTION 1702

SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
1	1		NA	NA	NA	NA	NA	NA	NA	NA	4
1	2		0.39	0.80	1.31	ND	0.66	ND	2.40	ND	3
1	3		0.55	10.02	27.36	0.09	24.65	1.82	QCF	4.69	2
1	4		NA	NA	NA	NA	NA	NA	NA	NA	4
1	5		0.84	8.40	10.87	0.14	3.73	0.52	2.96	ND	8
1	6	X	0.81	2.11	2.02	ND	2.32	ND	2.46	ND	7
1	6	X	0.50	3.10	3.67	ND	2.39	0.36	2.74	0.35	6
1	7		1.51	7.21	6.70	ND	5.02	ND	4.64	0.79	7
1	8	X	NA	NA	NA	NA	NA	NA	NA	NA	4
1	8	X	1.18	5.01	6.34	ND	6.27	1.09	6.19	1.10	7
1	9		1.39	15.97	17.68	0.17	15.82	2.04	22.60	3.24	3
1	10		0.75	10.91	14.68	ND	19.61	1.93	24.39	3.20	2
1	11		0.81	8.86	18.08	0.09	14.52	1.50	47.88	1.11	1
1	12		1.50	13.53	32.35	0.21	26.07	38.83	26.55	11.43	8
1	13		0.98	2.69	3.79	ND	3.31	ND	5.38	0.66	7
1	14	X	1.08	10.29	13.10	ND	16.05	3.39	19.51	3.38	6
1	14	X	1.17	12.36	14.75	ND	25.92	ND	42.81	ND	3
1	15		1.20	18.51	21.76	0.07	69.70	9.83	72.16	12.20	4
1	16	X	0.55	5.28	13.30	ND	10.88	2.04	24.17	2.66	2
1	16	X	0.62	6.98	11.34	ND	13.73	3.33	24.14	2.97	6
1	17		0.40	1.32	3.53	ND	1.78	0.28	1.89	0.40	2
1	18	X	0.88	6.97	9.12	0.09	10.68	1.20	10.87	1.87	1
1	18	X	0.97	11.25	15.60	ND	18.29	2.32	22.29	3.05	8
1	19		0.94	8.65	11.48	0.10	5.72	0.79	7.14	1.09	8
1	20		QCF	QCF	QCF	ND	QCF	QCF	QCF	QCF	7
1	21		QCF	QCF	QCF	ND	QCF	QCF	QCF	QCF	6
1	22		0.52	4.76	7.80	0.06	4.98	ND	4.57	0.94	4
1	23		0.82	5.62	6.46	ND	6.10	ND	7.65	1.42	3
1	24		0.88	4.88	8.32	ND	6.18	0.57	11.77	1.28	2
1	25		0.56	1.12	1.41	0.07	1.16	0.30	2.92	0.36	1
1	26	X	0.95	5.41	7.76	0.17	4.81	1.21	7.63	1.30	1
1	26	X	1.06	6.93	10.91	ND	7.19	ND	13.25	1.87	7
1	27		0.75	6.82	11.44	0.07	7.88	1.39	11.58	ND	6
1	27		0.83	7.56	12.00	ND	7.88	1.43	11.72	1.80	6
1	28		1.64	18.06	27.04	ND	20.50	3.46	55.51	4.24	8
1	29		1.33	11.35	QCF	ND	14.49	1.77	26.63	2.66	3
1	30		0.76	4.76	9.04	ND	6.19	0.70	10.73	1.14	2
1	31		0.20	0.15	0.11	ND	ND	ND	ND	ND	3

LEGEND:

QCF = SAMPLE ANALYSED BUT FAILED QC CRITERIA
NAC = NOT ANALYSED - CONTINGENCY SAMPLE
ND = SAMPLE ANALYSED,ANALYTE NOT DETECTED
NA = SAMPLE NOT ANALYSED
NT = SAMPLE NOT TAKEN/COLLECTED

SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
1	32		1.50	15.73	30.80	ND	18.06	1.79	28.07	2.92	8
1	33		1.01	6.26	10.47	0.14	3.71	ND	3.64	ND	8
1	34	X	QCF	QCF	QCF	ND	QCF	QCF	QCF	QCF	7
1	34	X	1.22	10.99	18.61	ND	8.25	1.13	9.01	1.58	6
1	35		2.47	24.02	50.20	0.17	15.36	1.65	18.28	3.09	4
1	36		5.65	45.11	QCF	ND	34.68	ND	44.89	9.53	3
1	37		2.68	24.82	44.23	0.14	13.79	1.71	17.51	2.43	2
1	38		0.92	6.68	14.31	0.15	18.44	2.08	45.14	2.95	1
1	39		4.22	41.74	50.77	ND	35.09	3.74	38.99	5.88	8
1	40		2.22	13.84	18.84	ND	QCF	5.82	101.72	20.99	7
1	41		3.56	31.68	67.20	ND	18.12	ND	28.12	4.74	6
1	42		QCF	QCF	QCF	QCF	QCF	ND	QCF	QCF	4
1	43		NT	NT	NT	NT	NT	NT	NT	NT	
1	44		NT	NT	NT	NT	NT	NT	NT	NT	
1	45		NT	NT	NT	NT	NT	NT	NT	NT	
1	46		2.46	12.13	23.09	ND	7.51	1.80	7.07	1.55	7
1	47		1.23	8.69	12.76	ND	3.78	0.81	3.42	0.80	6
1	48		QCF	QCF	QCF	QCF	QCF	QCF	QCF	QCF	4
1	49		1.79	10.85	QCF	ND	13.21	ND	8.05	2.93	3
1	50		QCF	5.65	8.32	0.06	6.10	ND	6.12	0.92	2
1	895		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
1	896		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
1	897		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
1	898		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
1	899		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
1	900		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
1	962		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
2	51		NA	NA	NA	NA	NA	NA	NA	NA	4
2	52		0.35	1.90	3.16	ND	0.51	0.26	ND	0.20	3
2	53		0.64	4.79	6.97	ND	3.92	1.47	2.20	1.07	2
2	54		0.46	1.05	1.70	0.09	0.28	0.16	0.18	0.09	1
2	55	X	NA	NA	NA	NA	NA	NA	NA	NA	4
2	55	X	0.29	0.46	0.70	0.03	0.31	0.16	ND	0.13	8
2	56		0.61	1.82	3.18	ND	0.60	0.53	0.27	0.20	7
2	57		0.52	1.85	2.49	0.04	0.78	ND	0.13	0.15	6
2	58		NA	NA	NA	NA	NA	NA	NA	NA	4
2	59		0.25	0.49	0.53	ND	0.21	ND	0.21	ND	3
2	60	X	NA	NA	NA	NA	NA	NA	NA	NA	4

LEGEND:

QCF = SAMPLE ANALYSED BUT FAILED QC CRITERIA
NAC = NOT ANALYSED - CONTINGENCY SAMPLE
ND = SAMPLE ANALYSED,ANALYTE NOT DETECTED
NA = SAMPLE NOT ANALYSED
NT = SAMPLE NOT TAKEN/COLLECTED

SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
2	60	X	0.21	0.19	0.23	ND	0.10	ND	ND	ND	2
2	61		0.17	0.35	0.67	ND	ND	ND	ND	ND	8
2	62		0.20	0.82	1.06	0.06	0.18	0.10	ND	ND	8
2	63		QCF	QCF	QCF	QCF	QCF	QCF	ND	ND	7
2	63		QCF	QCF	QCF	QCF	QCF	ND	QCF	ND	7
2	65	X	0.75	1.66	2.46	0.12	0.61	0.25	0.68	0.17	1
2	65	X	0.37	1.42	QCF	0.09	0.77	0.22	0.56	0.16	4
2	66		0.61	3.81	5.49	ND	1.40	ND	0.53	ND	3
2	67		0.44	1.78	2.29	ND	0.67	ND	ND	ND	2
2	68		1.26	7.14	11.09	0.10	5.54	1.74	4.26	1.20	1
2	69		0.80	5.09	8.57	0.17	1.53	0.47	1.59	ND	8
2	70		QCF	QCF	QCF	ND	QCF	ND	ND	QCF	7
2	70		QCF	QCF	QCF	ND	QCF	QCF	QCF	QCF	7
2	71		NA	NA	NA	NA	NA	NA	NA	NA	6
2	72		QCF	QCF	QCF	QCF	QCF	QCF	QCF	QCF	4
2	72		QCF	QCF	QCF	QCF	QCF	QCF	QCF	QCF	4
2	73		1.23	11.18	10.71	ND	4.20	ND	3.74	ND	3
2	74		0.41	1.51	2.31	ND	0.54	ND	ND	0.26	2
2	75		0.57	3.37	3.63	0.14	1.50	0.25	1.44	0.33	1
2	76	X	NA	NA	NA	NA	NA	NA	NA	NA	4
2	76	X	QCF	QCF	QCF	QCF	QCF	ND	QCF	QCF	7
2	77		4.84	52.60	66.66	0.24	7.17	2.33	6.77	1.25	6
2	78		NA	NA	NA	NA	NA	NA	NA	NA	4
2	79		0.47	1.39	1.60	ND	0.25	ND	ND	ND	3
2	80		0.68	1.25	0.97	QCF	0.28	0.27	0.39	4.80	2
2	81		1.73	1.23	1.37	0.15	0.24	0.15	ND	0.05	1
2	82		0.19	0.65	0.96	0.06	0.19	0.11	ND	ND	8
2	83		QCF	QCF	QCF	QCF	ND	ND	ND	ND	7
2	84	X	QCF	QCF	QCF	QCF	QCF	QCF	ND	ND	7
2	84	X	0.35	0.75	0.94	ND	0.36	0.20	0.20	0.10	6
2	85		0.23	0.32	0.26	0.04	0.21	ND	0.09	0.05	4
2	86		0.30	0.83	0.68	0.04	0.31	ND	0.45	0.16	3
2	87		0.28	0.57	0.84	ND	ND	ND	ND	ND	2
2	88		QCF	0.17	0.27	0.05	ND	ND	ND	ND	1
2	89		0.33	0.69	1.39	0.08	0.35	0.25	0.56	0.17	8
2	90	X	0.40	0.92	0.60	0.16	0.87	0.68	0.40	0.32	1
2	90	X	QCF	QCF	QCF	ND	QCF	QCF	QCF	QCF	7
2	91		0.50	1.59	1.53	ND	0.28	ND	ND	ND	6

LEGEND:

QCF = SAMPLE ANALYSED BUT FAILED QC CRITERIA
NAC = NOT ANALYSED - CONTINGENCY SAMPLE
ND = SAMPLE ANALYSED,ANALYTE NOT DETECTED
NA = SAMPLE NOT ANALYSED
NT = SAMPLE NOT TAKEN/COLLECTED

SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
2	92		0.31	0.36	0.48	0.08	ND	ND	0.10	ND	4
2	93		0.22	0.87	1.11	0.04	0.48	ND	0.43	0.27	3
2	94		0.23	0.32	0.31	ND	ND	ND	ND	ND	2
2	95		QCF	0.30	0.47	0.06	0.11	0.03	ND	0.03	1
2	96		0.88	0.38	0.26	ND	ND	ND	ND	ND	7
2	97		0.47	2.38	2.77	0.07	0.66	0.25	0.49	0.16	6
2	98		0.39	1.66	2.46	0.10	1.38	0.60	1.43	0.40	4
2	99	X	0.60	0.45	0.54	QCF	ND	0.14	ND	ND	7
2	99	X	0.29	0.49	0.67	ND	ND	ND	ND	ND	2
2	100		0.32	1.46	1.93	ND	0.35	0.11	0.16	ND	6
2	101		NA	NA	NA	NA	NA	NA	NA	NA	4
2	102		0.88	1.83	2.19	ND	0.53	0.37	0.45	0.49	6
2	103	X	0.28	0.47	0.60	ND	ND	ND	0.07	ND	2
2	103	X	0.25	0.74	0.84	ND	ND	ND	ND	ND	3
2	104		ND	0.43	0.77	0.07	0.19	0.11	0.19	0.08	1
2	105		0.13	0.22	0.31	0.05	0.06	ND	ND	ND	8
2	106		0.67	0.39	0.48	ND	0.16	0.05	0.17	ND	7
2	107		0.34	1.55	2.11	ND	0.51	0.42	0.61	ND	6
2	108		NA	NA	NA	NA	NA	NA	NA	NA	4
2	109		QCF	QCF	QCF	QCF	QCF	ND	QCF	ND	7
2	110		NA	NA	NA	NA	NA	NA	NA	NA	4
2	111		0.49	1.20	1.50	0.08	0.40	ND	0.43	ND	1
2	112		0.20	0.21	0.23	0.04	0.08	ND	ND	ND	8
2	113		0.93	1.60	1.48	ND	1.47	ND	ND	1.63	7
2	114		3.43	5.13	8.36	ND	5.92	0.83	1.65	2.19	6
2	115		NA	NA	NA	NA	NA	NA	NA	NA	4
2	116		QCF	QCF	QCF	ND	ND	ND	ND	ND	3
2	117	X	NA	NA	NA	NA	NA	NA	NA	NA	4
2	117	X	0.40	0.52	0.54	ND	ND	ND	ND	ND	2
2	118		0.42	0.56	0.38	0.07	0.11	ND	0.14	ND	1
2	119	X	0.25	0.41	0.62	ND	0.18	ND	ND	ND	6
2	119	X	0.23	0.35	0.66	0.07	0.16	ND	0.19	ND	8
2	120		QCF	QCF	QCF	QCF	QCF	ND	ND	ND	7
2	121		0.39	1.95	2.00	0.05	0.56	0.20	0.39	0.11	6
2	122		NA	NA	NA	NA	NA	NA	NA	NA	4
2	123		0.21	0.40	0.37	0.06	ND	ND	ND	ND	8
2	124		0.30	0.75	0.72	ND	0.28	ND	ND	ND	2
2	125		QCF	QCF	QCF	ND	ND	ND	ND	ND	3

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
2	126		QCF	QCF	QCF	QCF	QCF	ND	QCF	ND	7
2	127		0.29	0.81	1.11	0.04	0.34	0.07	ND	0.09	6
2	128		NA	NA	NA	NA	NA	NA	NA	NA	4
2	129	X	QCF	0.61	0.81	0.05	0.34	ND	0.45	0.13	1
2	129	X	0.32	1.25	1.72	0.06	0.86	0.31	1.12	0.36	6
2	130		0.29	0.64	0.91	0.04	0.45	ND	0.51	0.15	2
2	131		QCF	0.91	1.23	0.09	0.40	0.26	0.39	0.15	1
2	132		0.30	1.36	1.57	0.01	0.82	0.16	1.47	0.14	8
2	133		1.01	0.84	0.97	ND	1.30	0.55	ND	0.51	7
2	135		NA	NA	NA	NA	NA	NA	NA	NA	4
2	136		19.80	167.33	44.83	ND	100.31	ND	29.97	6.67	3
2	137	X	0.59	0.60	0.65	0.06	0.48	0.06	QCF	ND	2
2	137	X	0.26	0.81	1.09	0.06	0.83	ND	0.63	0.14	8
2	138		QCF	0.64	0.75	0.13	0.19	ND	QCF	ND	1
2	139		0.29	1.79	2.06	0.07	0.50	ND	0.48	ND	8
2	140		QCF	QCF	QCF	QCF	QCF	ND	ND	ND	7
2	142		NA	NA	NA	NA	NA	NA	NA	NA	4
2	143		0.42	1.05	1.78	0.08	0.73	ND	0.76	0.14	3
2	144		0.66	0.61	1.05	0.08	1.25	ND	QCF	0.25	2
2	145		QCF	1.05	1.06	0.13	0.86	0.15	1.82	0.26	1
2	146		0.76	0.85	1.12	ND	0.73	ND	1.42	ND	7
2	147		0.54	2.75	4.12	0.08	2.54	0.86	2.78	0.93	6
2	148		NA	NA	NA	NA	NA	NA	NA	NA	4
2	149		0.23	1.19	1.55	0.04	1.48	0.43	1.49	0.37	3
2	150		0.21	0.67	1.21	0.06	0.72	0.09	ND	0.22	8
2	901		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
2	902		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
2	903		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
2	904		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
2	905		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
2	906		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
2	907		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
2	908		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
2	64R		0.96	7.96	9.85	0.07	1.50	0.66	1.13	ND	6
2	141R		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	6
2	134R		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
3	151		0.31	0.46	0.32	0.07	ND	ND	ND	ND	3
3	152		0.17	0.08	ND	0.06	0.01	ND	ND	ND	2

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
3	153		0.48	1.71	2.79	0.08	0.60	ND	0.46	ND	1
3	154		0.12	0.21	0.19	ND	0.11	ND	ND	0.06	8
3	155		0.75	0.57	0.42	0.10	0.33	0.19	ND	0.15	7
3	156	X	NA	NA	NA	NA	NA	NA	NA	NA	4
3	156	X	1.37	0.82	0.65	0.04	0.22	ND	ND	ND	6
3	157		NA	NA	NA	NA	NA	NA	NA	NA	4
3	158		0.43	1.49	0.57	ND	ND	ND	ND	ND	3
3	159		ND	1.03	0.81	ND	ND	ND	ND	ND	3
3	160	X	0.50	1.85	1.89	0.09	ND	ND	ND	0.32	1
3	160	X	0.28	1.20	1.29	0.06	0.16	ND	ND	ND	2
3	161		0.24	0.72	1.21	0.07	0.19	0.17	0.37	0.22	8
3	162		1.19	1.57	2.49	ND	0.61	ND	ND	ND	7
3	163	X	0.24	0.38	0.58	0.04	0.15	ND	ND	ND	6
3	163	X	0.30	0.61	0.92	ND	0.36	ND	0.14	ND	3
3	164		NA	NA	NA	NA	NA	NA	NA	NA	4
3	165		0.43	1.68	1.93	0.05	ND	ND	ND	ND	3
3	166		0.22	0.56	1.14	ND	0.27	ND	ND	ND	2
3	168	X	QCF	1.25	2.63	0.06	0.33	ND	0.30	0.13	1
3	168	X	0.21	0.89	1.93	0.04	0.28	0.29	0.71	ND	8
3	169		1.42	4.85	9.55	ND	4.06	79.99	27.91	ND	7
3	170		0.29	0.96	3.47	ND	ND	ND	0.45	0.38	6
3	171		NA	NA	NA	NA	NA	NA	NA	NA	4
3	172		0.27	1.41	1.79	ND	0.32	0.12	0.35	ND	3
3	173		0.27	0.29	0.33	ND	ND	ND	ND	ND	2
3	174		0.78	4.25	3.44	0.09	0.94	0.19	1.27	0.34	8
3	175		1.05	4.92	2.71	ND	5.06	ND	ND	12.68	7
3	176		0.26	1.14	0.91	ND	1.31	1.81	0.62	1.93	6
3	177		QCF	QCF	QCF	QCF	ND	ND	ND	ND	4
3	178		0.46	1.33	1.29	ND	0.30	ND	0.15	ND	3
3	179		0.42	0.57	0.44	0.09	0.14	ND	ND	ND	2
3	180		0.31	0.77	0.76	0.10	0.27	0.12	0.26	0.26	1
3	181	X	0.34	0.30	0.27	0.14	0.08	0.05	ND	0.02	1
3	181	X	0.27	0.43	0.38	0.08	ND	ND	ND	ND	8
3	182		0.66	0.65	0.62	0.10	ND	ND	ND	ND	7
3	183		0.73	6.70	4.48	ND	3.28	0.50	2.60	0.97	6
3	184		QCF	QCF	QCF	QCF	QCF	ND	QCF	QCF	4
3	185		0.38	1.54	2.27	ND	0.46	ND	ND	ND	3
3	186		QCF	QCF	QCF	QCF	QCF	ND	ND	ND	2

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
3	187		0.43	0.57	0.55	0.09	0.20	0.10	0.14	0.06	1
3	188		0.32	0.82	1.06	0.10	0.26	0.10	ND	ND	8
3	189		0.98	1.79	2.16	ND	ND	ND	24.69	2.39	7
3	190		0.34	0.92	1.36	0.06	0.27	ND	0.24	0.15	6
3	191		NA	NA	NA	NA	NA	NA	NA	NA	4
3	192		2.52	3.87	2.49	ND	12.84	ND	QCF	ND	3
3	192		2.37	3.63	2.48	ND	10.86	ND	13.68	0.47	3
3	193		QCF	0.48	0.78	0.09	0.17	ND	ND	ND	2
3	194		0.39	0.73	0.74	0.12	0.14	ND	ND	0.05	1
3	195		1.11	2.44	2.36	ND	0.55	0.42	ND	0.20	7
3	196		0.39	1.68	1.88	ND	0.50	0.27	0.33	ND	6
3	197		NA	NA	NA	NA	NA	NA	NA	NA	4
3	198	X	QCF	0.29	0.30	0.06	0.12	ND	ND	ND	2
3	198	X	0.32	0.62	0.52	0.06	0.20	ND	ND	ND	3
3	199		0.53	1.08	1.40	ND	0.44	ND	0.47	0.20	2
3	200		QCF	0.37	0.41	0.10	0.09	ND	ND	0.01	1
3	201	X	QCF	0.36	0.43	0.06	ND	ND	ND	ND	2
3	201	X	0.73	0.35	0.47	QCF	0.13	ND	0.22	ND	8
3	202		QCF	7.65	6.49	QCF	QCF	QCF	14.69	1.70	7
3	203		NT	NT	NT	NT	NT	NT	NT	NT	
3	204		QCF	QCF	QCF	QCF	ND	QCF	QCF	QCF	4
3	204		QCF	QCF	QCF	ND	ND	QCF	QCF	QCF	4
3	205		0.52	1.06	0.92	QCF	ND	ND	0.13	ND	3
3	206		QCF	0.32	0.26	ND	ND	ND	ND	ND	2
3	207		QCF	0.55	0.37	0.10	0.14	ND	0.07	0.03	1
3	208		0.62	1.30	1.09	QCF	1.85	0.26	1.87	0.34	8
3	209		QCF	QCF	QCF	ND	ND	ND	ND	ND	7
3	210		0.48	3.45	4.50	ND	0.78	0.75	0.91	ND	6
3	211		QCF	QCF	QCF	QCF	QCF	QCF	QCF	QCF	4
3	212		NA	NA	NA	NA	NA	NA	NA	NA	3
3	213		QCF	0.90	0.69	ND	1.66	ND	3.53	0.50	2
3	214		QCF	0.71	0.87	0.10	0.18	0.11	0.75	0.06	1
3	215		0.78	1.05	1.43	QCF	0.33	ND	0.26	ND	7
3	216		0.37	1.00	1.59	ND	0.39	0.49	1.22	0.17	6
3	217		QCF	QCF	QCF	QCF	ND	ND	QCF	ND	4
3	218		0.42	1.84	2.75	ND	0.65	0.45	0.66	0.21	3
3	219		QCF	0.13	0.10	ND	0.06	ND	0.06	ND	2
3	220		QCF	0.36	0.37	0.10	0.08	ND	0.12	ND	1

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
3	221	X	0.70	0.97	1.48	ND	0.27	0.27	ND	0.14	7
3	221	X	0.25	1.28	1.77	0.05	0.24	ND	ND	ND	8
3	223		NA	NA	NA	NA	NA	NA	NA	NA	4
3	224		0.64	1.22	1.89	ND	ND	ND	ND	ND	3
3	225	X	0.39	1.13	1.98	0.09	0.87	ND	QCF	0.26	2
3	225	X	0.49	3.62	7.12	ND	499.09	ND	216.20	6.71	8
3	226		0.75	6.25	5.39	0.05	16.05	2.11	51.17	7.73	6
3	227	X	0.29	0.65	1.00	0.12	1.10	ND	1.73	0.31	8
3	227	X	QCF	QCF	QCF	ND	QCF	ND	QCF	QCF	3
3	228	X	0.66	0.83	1.03	ND	1.13	ND	1.30	ND	7
3	228	X	0.73	0.91	1.10	0.10	1.38	0.21	1.59	0.52	7
3	229		0.38	1.46	1.47	ND	0.90	0.22	0.85	0.24	6
3	230		NA	NA	NA	NA	NA	NA	NA	NA	4
3	231		0.66	2.32	3.04	ND	0.24	ND	ND	ND	3
3	2[illegible]1		0.30	0.75	1.43	ND	ND	ND	ND	0.05	3
3	232		0.29	0.72	0.66	ND	0.34	ND	0.34	ND	2
3	233		0.50	0.71	0.65	0.12	0.64	ND	0.61	0.17	1
3	234		0.47	2.22	1.89	ND	0.93	ND	0.88	0.26	8
3	235		QCF	QCF	QCF	ND	QCF	ND	ND	QCF	7
3	236		0.21	0.35	0.36	ND	0.08	ND	ND	0.15	5
3	237		NA	NA	NA	NA	NA	NA	NA	NA	4
3	238		QCF	QCF	QCF	ND	QCF	ND	QCF	ND	3
3	239		0.31	0.92	0.95	ND	0.22	ND	ND	ND	2
3	240	X	NA	NA	NA	NA	NA	NA	NA	NA	4
3	240	X	0.40	0.89	1.09	0.05	0.29	ND	0.18	ND	1
3	241		0.18	0.38	0.55	0.06	0.16	ND	ND	ND	8
3	242		0.73	2.60	2.24	ND	0.17	ND	ND	ND	8
3	243		0.47	1.36	1.72	0.04	0.30	ND	ND	ND	6
3	244		0.35	0.54	1.22	0.15	0.12	ND	ND	ND	8
3	245		0.65	1.70	1.08	ND	ND	ND	0.52	ND	3
3	246	X	0.44	0.57	0.55	ND	ND	ND	ND	ND	2
3	246	X	0.42	1.22	1.16	ND	0.10	ND	ND	ND	3
3	247		0.42	0.24	0.34	0.10	0.08	0.13	0.15	0.02	1
3	248		QCF	QCF	QCF	QCF	QCF	QCF	ND	ND	7
3	249	X	0.31	0.23	0.27	0.11	ND	ND	ND	ND	2
3	249	X	0.16	0.29	0.49	ND	ND	ND	ND	ND	6
3	250		NA	NA	NA	NA	NA	NA	NA	NA	4
3	251		0.32	0.29	0.28	ND	ND	ND	ND	ND	3

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TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
3	252	X	NA	NA	NA	NA	NA	NA	NA	NA	4
3	252	X	QCF	QCF	QCF	QCF	ND	ND	ND	ND	2
3	253		0.46	0.31	0.45	0.09	ND	0.05	ND	ND	1
3	254		0.33	0.75	1.20	0.12	0.87	0.16	0.99	0.18	8
3	255	X	0.55	0.82	1.32	0.12	0.20	ND	0.09	ND	1
3	255	X	QCF	QCF	QCF	QCF	QCF	ND	ND	ND	7
3	909		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
3	910		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
3	911		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
3	912		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
3	955		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
3	956		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
3	167R		0.36	0.24	0.37	ND	0.08	ND	ND	ND	1
3	981		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
3	222R		0.40	1.12	1.07	0.05	0.37	0.16	0.27	0.12	6
4	256		0.71	0.23	0.17	0.11	ND	ND	ND	ND	7
4	257		2.23	0.22	0.19	0.05	0.04	ND	ND	ND	6
4	258		NA	NA	NA	NA	NA	NA	NA	NA	4
4	259		0.30	0.53	0.42	ND	0.05	ND	ND	ND	3
4	260		0.25	0.40	0.35	0.06	ND	ND	ND	ND	2
4	261		0.29	0.32	0.34	0.05	ND	ND	ND	ND	1
4	262		0.14	0.54	0.47	ND	0.15	ND	ND	0.14	8
4	263		0.54	0.33	0.33	0.11	ND	0.08	0.12	ND	7
4	264		1.09	3.67	3.80	0.09	2.36	0.98	2.89	ND	6
4	265		NA	NA	NA	NA	NA	NA	NA	NA	4
4	266		0.45	0.96	0.54	0.05	ND	ND	ND	ND	3
4	267		0.36	1.13	1.16	0.07	0.81	0.29	0.36	ND	2
4	268		0.52	1.38	1.51	0.13	1.41	0.40	ND	ND	1
4	269		0.16	0.75	QCF	QCF	0.60	0.31	0.42	0.20	8
4	269		0.17	0.75	QCF	QCF	0.61	0.33	0.41	0.18	8
4	270		ND	11.92	15.51	ND	152.53	ND	1729.10	47.05	7
4	271	X	NA	NA	NA	NA	NA	NA	NA	NA	4
4	271	X	0.91	1.76	1.46	ND	9.94	ND	82.47	0.65	6
4	272		0.39	1.75	2.01	ND	0.74	ND	1.17	0.15	6
4	273	X	0.31	0.41	0.63	0.01	0.08	ND	ND	ND	6
4	273	X	0.27	0.44	0.35	0.06	0.07	ND	ND	ND	3
4	274		0.28	0.42	0.28	0.09	0.20	ND	ND	ND	2
4	275		QCF	QCF	QCF	QCF	QCF	ND	QCF	ND	7

LEGEND:

QCF = SAMPLE ANALYSED BUT FAILED QC CRITERIA
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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
4	276		0.13	0.22	0.25	0.04	ND	ND	ND	ND	8
4	277		0.56	0.69	0.26	0.09	0.54	ND	0.41	ND	7
4	278		0.35	0.36	0.34	0.02	ND	ND	ND	ND	6
4	279		NA	NA	NA	NA	NA	NA	NA	NA	4
4	280		0.29	0.37	0.32	ND	0.07	ND	ND	ND	3
4	281		0.31	0.47	0.58	ND	ND	ND	0.20	ND	2
4	282		0.37	0.14	0.10	ND	ND	ND	ND	ND	1
4	283		0.51	0.11	0.04	0.10	ND	ND	ND	ND	7
4	284		0.17	0.22	0.16	0.03	ND	ND	ND	ND	6
4	285		NA	NA	NA	NA	NA	NA	NA	NA	4
4	286		QCF	QCF	QCF	QCF	QCF	QCF	ND	ND	3
4	287		0.43	0.30	0.20	0.08	ND	ND	ND	ND	2
4	288		0.44	0.21	0.16	0.11	0.03	ND	ND	ND	1
4	289		0.31	0.32	0.31	0.10	0.27	ND	ND	NL	8
4	290		0.49	0.19	0.11	QCF	0.08	ND	0.05	ND	7
4	291		0.36	0.37	0.38	ND	ND	ND	ND	ND	6
4	292		NA	NA	NA	NA	NA	NA	NA	NA	4
4	293		0.25	0.71	1.61	ND	0.08	ND	ND	ND	3
4	294		0.24	0.28	0.23	0.04	1.96	ND	1.81	ND	2
4	295		0.36	0.38	0.35	0.09	0.06	ND	ND	0.04	1
4	296	X	0.37	0.48	0.31	0.07	0.12	ND	0.77	0.04	1
4	296	X	ND	0.26	0.25	0.04	ND	ND	ND	ND	8
4	297		0.85	4.07	5.44	ND	4.04	ND	2.99	0.77	7
4	298		0.32	0.53	0.44	0.04	0.15	0.14	ND	ND	6
4	298		0.30	0.47	0.45	0.05	0.16	ND	0.14	ND	6
4	299		NA	NA	NA	NA	NA	NA	NA	NA	4
4	300		0.48	1.98	1.32	ND	1.51	ND	1.36	0.11	3
4	301		QCF	QCF	QCF	ND	QCF	QCF	QCF	ND	7
4	302		ND	ND	8.46	ND	129.90	ND	4108.31	85.60	1
4	303		0.53	0.53	0.45	ND	0.09	ND	ND	ND	7
4	304		0.53	2.40	2.35	ND	0.86	1.93	1.26	ND	6
4	305		0.21	1.36	1.02	ND	16.29	3.04	241.25	5.76	4
4	307		QCF	0.41	0.39	0.03	ND	ND	0.12	ND	2
4	308		0.40	0.15	0.13	0.13	ND	ND	ND	0.03	1
4	309		0.56	0.28	0.25	QCF	0.08	ND	ND	ND	8
4	310		0.66	0.26	0.21	0.09	0.05	ND	ND	ND	7
4	311		0.28	1.09	0.64	ND	0.27	ND	0.18	0.72	6
4	312		NA	NA	NA	NA	NA	NA	NA	NA	4

LEGEND:

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
4	313		0.30	0.49	0.43	ND	0.13	ND	ND	ND	3
4	314		QCF	QCF	QCF	QCF	QCF	ND	QCF	ND	2
4	315		0.47	1.86	1.15	0.11	1.10	0.26	2.03	16.33	1
4	316		0.50	0.94	0.47	ND	10.47	ND	41.17	0.82	8
4	317		QCF	QCF	QCF	ND	QCF	QCF	QCF	ND	7
4	318		0.38	1.16	0.89	0.05	0.49	0.12	0.47	0.16	6
4	319		NA	NA	NA	NA	NA	NA	NA	NA	4
4	320		0.50	12.08	182.41	ND	0.77	ND	ND	ND	3
4	321		QCF	QCF	QCF	QCF	QCF	ND	ND	QCF	2
4	322		QCF	QCF	QCF	QCF	QCF	ND	ND	QCF	1
4	322		QCF	QCF	QCF	QCF	QCF	ND	QCF	QCF	1
4	323		QCF	QCF	QCF	QCF	QCF	ND	QCF	ND	7
4	324		0.22	0.39	0.31	ND	ND	0.10	0.07	0.81	6
4	325		NA	NA	NA	NA	NA	NA	NA	NA	4
4	326		0.39	0.71	0.52	0.07	0.18	ND	ND	0.20	3
4	327		QCF	QCF	QCF	ND	QCF	ND	QCF	QCF	2
4	328		0.39	0.48	0.48	ND	0.27	ND	0.10	0.12	1
4	329		0.42	0.18	ND	ND	0.12	ND	ND	ND	8
4	330		QCF	QCF	QCF	QCF	QCF	ND	ND	ND	7
4	331		0.29	0.62	0.98	0.05	0.94	0.12	0.64	0.12	6
4	332		NA	NA	NA	NA	NA	NA	NA	NA	4
4	333		0.29	0.43	0.32	0.07	0.37	ND	0.22	ND	3
4	334		QCF	QCF	QCF	ND	QCF	ND	ND	ND	2
4	335		QCF	QCF	QCF	QCF	QCF	QCF	ND	QCF	1
4	335		QCF	QCF	QCF	QCF	QCF	ND	ND	QCF	1
4	336		0.31	0.41	0.48	QCF	0.12	ND	ND	ND	8
4	337		QCF	QCF	QCF	QCF	ND	ND	ND	ND	7
4	338		0.22	0.34	0.38	0.04	0.14	ND	0.16	ND	6
4	339		NA	NA	NA	NA	NA	NA	NA	NA	4
4	340		0.36	0.91	0.80	ND	0.28	ND	ND	0.09	3
4	913		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
4	914		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
4	915		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
4	916		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
4	917		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
4	918		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
4	965		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
4	966		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	

LEGEND:

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
5	306		0.32	0.26	0.18	ND	ND	ND	0.03	ND	3
5	341		0.36	0.20	0.17	0.10	0.05	ND	ND	ND	1
5	342		QCF	QCF	QCF	ND	ND	ND	ND	ND	8
5	342		QCF	QCF	QCF	QCF	ND	ND	ND	ND	8
5	343		0.48	0.21	0.10	QCF	0.05	ND	0.07	ND	7
5	344		0.42	1.07	1.05	0.07	ND	ND	ND	ND	6
5	345		0.25	1.13	0.92	0.05	ND	0.06	ND	ND	8
5	346		NA	NA	NA	NA	NA	NA	NA	NA	4
5	347		0.39	1.12	1.52	ND	0.65	ND	0.26	0.33	2
5	348		0.52	2.02	1.73	0.10	2.36	0.13	1.20	0.21	1
5	349		QCF	QCF	QCF	QCF	QCF	ND	ND	QCF	8
5	349		QCF	QCF	QCF	QCF	QCF	ND	ND	ND	8
5	350		0.47	0.20	0.19	0.10	ND	ND	ND	ND	7
5	351		0.30	0.84	0.28	0.09	0.27	0.03	ND	ND	8
5	352		NA	NA	NA	NA	NA	NA	NA	NA	4
5	353		QCF	QCF	QCF	ND	ND	ND	ND	ND	3
5	354	X	0.68	0.29	0.18	0.08	0.04	ND	ND	ND	7
5	354	X	0.36	0.35	0.22	ND	0.04	ND	ND	ND	2
5	355		0.44	0.29	0.22	0.08	ND	ND	ND	ND	1
5	356		0.33	0.44	0.34	0.11	ND	ND	ND	ND	8
5	357		0.93	0.32	0.23	0.11	ND	ND	ND	ND	7
5	358		0.31	0.96	3.29	ND	ND	ND	ND	ND	6
5	359		NA	NA	NA	NA	NA	NA	NA	NA	4
5	360		1.19	2.97	2.61	ND	5.39	ND	24.72	2.21	3
5	361		0.58	1.33	2.35	ND	0.18	ND	ND	ND	2
5	363		1.22	3.02	0.94	0.10	0.24	ND	0.31	ND	7
5	364		0.41	0.58	0.62	0.04	ND	ND	ND	ND	6
5	365		0.35	1.07	1.19	0.11	1.00	0.14	0.42	0.22	4
5	366		0.59	1.44	1.10	ND	ND	0.06	ND	ND	3
5	367	X	0.47	1.41	0.93	ND	0.40	ND	ND	ND	2
5	367	X	0.86	3.02	2.13	0.10	0.99	ND	0.50	ND	6
5	368		1.04	3.44	2.46	0.10	1.55	0.70	0.27	1.41	1
5	369	X	0.18	0.09	QCF	0.06	ND	ND	ND	ND	4
5	369	X	0.14	0.10	0.12	0.04	ND	ND	ND	ND	8
5	370		QCF	QCF	QCF	QCF	QCF	ND	ND	QCF	7
5	371		0.63	0.60	0.47	0.09	0.55	0.25	0.39	ND	7
5	372		0.39	0.46	QCF	0.09	ND	ND	0.16	ND	4
5	373		0.58	3.22	3.06	ND	3.32	ND	1.27	1.59	3

LEGEND:

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
5	374		0.33	0.43	0.43	ND	ND	ND	ND	ND	2
5	375		0.25	0.19	0.17	ND	ND	ND	ND	ND	2
5	376		0.26	0.36	0.48	ND	0.06	ND	ND	ND	1
5	377		0.34	0.31	0.33	0.11	ND	0.05	ND	ND	8
5	378		0.91	0.45	0.25	0.16	0.09	ND	ND	ND	7
5	379		0.26	0.26	0.17	0.02	ND	ND	ND	ND	6
5	380		NA	NA	NA	NA	NA	NA	NA	NA	4
5	381		QCF	QCF	QCF	ND	QCF	ND	ND	ND	3
5	382		0.27	0.34	0.33	0.05	0.17	0.06	ND	0.06	6
5	383	X	0.24	0.36	0.26	0.06	0.06	ND	0.07	ND	1
5	383	X	0.34	0.44	0.26	0.05	ND	ND	ND	ND	2
5	384		0.14	0.27	0.29	0.04	ND	ND	ND	ND	8
5	385		1.09	4.14	5.56	ND	1.16	ND	2.08	ND	7
5	386		3.19	35.65	51.97	ND	83.51	ND	663.49	13.30	6
5	387		NA	NA	NA	NA	NA	NA	NA	NA	4
5	388		0.39	0.59	0.38	0.07	0.04	ND	ND	ND	3
5	389		0.30	0.39	0.21	0.04	ND	ND	0.19	ND	2
5	390		0.86	2.28	1.39	0.07	0.60	0.19	0.77	0.18	1
5	391		0.57	0.61	0.43	ND	ND	0.09	ND	ND	8
5	392	X	0.25	0.14	0.09	0.05	ND	ND	0.10	ND	1
5	392	X	QCF	QCF	QCF	QCF	QCF	ND	QCF	ND	7
5	393		1.20	9.96	168.64	ND	57.60	9.96	89.45	26.33	6
5	393		1.19	10.93	QCF	0.03	QCF	10.11	QCF	QCF	6
5	394		NA	NA	NA	NA	NA	NA	NA	NA	4
5	395		0.29	0.68	0.48	0.07	0.31	ND	ND	ND	3
5	396		0.66	0.98	0.85	ND	0.20	ND	ND	0.06	2
5	397		0.87	3.48	6.61	0.12	4.33	0.84	2.80	4.68	1
5	398		1.73	11.14	18.40	ND	10.83	4.64	13.27	14.02	7
5	399		0.31	0.54	0.61	ND	0.13	ND	ND	0.05	6
5	400		NA	NA	NA	NA	NA	NA	NA	NA	4
5	401		NA	NA	NA	NA	NA	NA	NA	NA	3
5	402		QCF	QCF	QCF	ND	QCF	ND	ND	ND	2
5	403		0.57	2.07	0.60	0.13	0.20	ND	ND	ND	3
5	404		0.66	0.39	0.20	QCF	0.11	ND	ND	ND	8
5	405		QCF	QCF	QCF	QCF	QCF	ND	ND	ND	7
5	406		0.27	0.91	0.75	ND	0.16	ND	ND	0.04	6
5	407		NA	NA	NA	NA	NA	NA	NA	NA	4
5	408		0.30	0.50	0.28	ND	0.04	ND	ND	ND	3

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
5	409		0.31	0.17	0.14	ND	ND	ND	ND	ND	2
5	410		0.39	0.63	0.54	0.06	0.16	ND	ND	0.06	1
5	411		0.74	0.65	0.64	QCF	0.38	ND	ND	ND	7
5	412		0.29	0.41	0.40	ND	0.28	ND	ND	0.20	6
5	413		NA	NA	NA	NA	NA	NA	NA	NA	4
5	414		QCF	QCF	QCF	ND	QCF	ND	QCF	ND	3
5	415		0.18	0.31	0.22	0.03	ND	ND	ND	ND	2
5	416		0.36	0.08	ND	0.07	ND	ND	ND	ND	1
5	417	X	0.42	1.75	2.32	0.03	1.66	0.34	2.49	0.49	6
5	417	X	0.36	0.22	0.46	0.12	ND	ND	ND	ND	8
5	418		0.71	0.27	0.20	0.08	ND	ND	ND	ND	7
5	419		0.24	0.42	0.37	0.04	0.20	ND	ND	ND	6
5	420		NA	NA	NA	NA	NA	NA	NA	NA	4
5	421		NA	NA	NA	NA	NA	NA	NA	NA	4
5	422		0.17	0.22	0.12	0.05	ND	ND	ND	ND	2
5	423		0.50	0.67	0.39	ND	0.74	0.11	0.64	ND	1
5	424		0.40	0.82	0.51	0.15	0.58	0.13	0.48	ND	8
5	425		0.58	0.44	0.25	0.08	0.16	ND	ND	ND	7
5	426		0.25	0.47	0.49	0.06	0.21	ND	ND	0.22	6
5	427		NA	NA	NA	NA	NA	NA	NA	NA	4
5	428		0.50	1.91	QCF	ND	0.51	ND	ND	ND	3
5	429		0.45	1.16	1.22	ND	0.32	ND	ND	ND	2
5	430		0.36	0.40	0.33	0.08	0.17	ND	ND	0.04	1
5	431		0.54	1.83	2.59	0.12	0.94	0.17	1.11	0.32	8
5	432		QCF	QCF	QCF	ND	QCF	ND	ND	QCF	7
5	433		0.49	2.48	1.33	ND	0.94	0.23	0.68	ND	6
5	434		0.21	0.31	0.22	0.07	ND	ND	ND	ND	4
5	435		0.28	0.76	1.10	ND	0.14	ND	ND	ND	3
5	436	X	0.34	0.27	0.25	0.06	ND	ND	ND	ND	2
5	436	X	QCF	QCF	QCF	ND	QCF	ND	ND	ND	3
5	437		0.36	0.34	0.31	0.08	0.14	ND	ND	ND	1
5	438		0.87	0.30	0.21	0.08	0.16	ND	ND	ND	7
5	440		0.16	0.15	0.09	0.06	ND	ND	ND	ND	4
5	441		0.26	0.21	0.16	ND	ND	ND	ND	ND	3
5	442		0.32	0.34	0.24	0.07	ND	ND	ND	ND	2
5	443		0.37	0.29	0.25	0.08	0.03	ND	0.01	ND	1
5	445		QCF	QCF	QCF	QCF	QCF	ND	QCF	ND	7
5	919		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	

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SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
5	920		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	921		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	922		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	923		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	924		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	925		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	926		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	927		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	928		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	929		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	930		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	931		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	964		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	362R		0.40	0.86	0.82	0.07	0.21	ND	0.15	0.06	1
5	984		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	439R		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
5	444R		0.30	0.57	0.51	ND	0.19	ND	0.16	ND	6
6	481		QCF	QCF	QCF	ND	QCF	ND	ND	ND	2
6	482		0.36	0.21	0.13	0.07	ND	ND	ND	ND	1
6	483		0.27	0.49	0.39	0.06	0.18	ND	ND	ND	8
6	484		0.62	0.33	0.29	0.09	0.23	ND	ND	ND	7
6	485		0.26	0.55	0.44	ND	0.18	0.11	0.11	0.08	6
6	486		NA	NA	NA	NA	NA	NA	NA	NA	4
6	487		QCF	QCF	QCF	ND	ND	ND	ND	ND	3
6	488		QCF	QCF	QCF	ND	QCF	ND	ND	ND	2
6	489		0.38	0.52	0.38	ND	0.16	ND	0.14	ND	1
6	490		0.30	0.19	0.25	0.11	0.07	ND	ND	ND	8
6	491		0.68	0.38	0.22	0.05	ND	ND	ND	ND	7
6	493		0.21	0.13	0.04	0.08	ND	ND	ND	ND	4
6	494		0.23	0.19	0.11	ND	ND	ND	ND	ND	3
6	495		QCF	QCF	QCF	ND	ND	ND	ND	ND	2
6	496		0.56	0.34	0.32	0.10	0.08	ND	0.11	ND	1
6	497		0.22	0.15	0.11	0.05	ND	ND	ND	ND	8
6	498		0.65	0.51	0.46	ND	0.16	ND	0.36	ND	7
6	499		0.31	0.30	0.32	ND	ND	ND	ND	ND	6
6	500	X	0.52	0.28	0.30	0.05	ND	ND	ND	ND	1
6	500	X	0.25	0.18	0.14	0.11	ND	ND	ND	ND	4
6	501		0.43	0.87	0.73	ND	0.15	ND	ND	ND	3

LEGEND:

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
6	502		0.29	0.26	0.16	ND	ND	ND	ND	ND	2
6	503		0.48	0.30	0.61	0.09	0.43	ND	ND	0.89	1
6	504		0.78	1.20	0.83	0.11	0.36	ND	ND	ND	7
6	505		0.27	0.91	0.99	0.04	0.23	ND	ND	ND	6
6	506		0.26	0.19	0.15	0.10	ND	ND	0.21	ND	4
6	507		QCF	QCF	QCF	ND	ND	ND	ND	ND	3
6	508		0.31	0.40	0.34	ND	ND	ND	ND	ND	2
6	509		0.53	0.28	0.27	0.10	0.06	ND	0.10	ND	1
6	510		0.33	0.23	0.23	0.09	ND	ND	ND	ND	8
6	511		1.08	0.79	0.58	ND	0.33	3.44	1.04	ND	7
6	512		0.17	0.17	0.17	ND	ND	ND	ND	ND	6
6	513		NA	NA	NA	NA	NA	NA	NA	NA	4
6	514		0.20	0.11	0.08	0.03	ND	ND	ND	ND	3
6	515		0.30	0.79	0.41	ND	0.49	ND	0.59	0.43	2
6	516		0.28	0.71	0.66	0.08	0.29	ND	ND	ND	2
6	517		0.35	0.52	0.47	ND	0.07	ND	ND	ND	1
6	518		0.35	0.57	0.61	ND	0.19	ND	ND	ND	8
6	519		0.76	0.53	0.33	0.13	0.11	ND	ND	0.04	7
6	520		0.28	0.37	0.24	ND	0.07	ND	ND	ND	6
6	521		NA	NA	NA	NA	NA	NA	NA	NA	4
6	522		QCF	QCF	QCF	QCF	QCF	ND	QCF	ND	3
6	523		0.23	0.39	0.28	0.05	ND	ND	ND	ND	2
6	524		0.44	0.26	0.22	0.08	ND	ND	ND	ND	1
6	525	X	0.29	0.13	0.05	0.05	ND	0.06	ND	ND	1
6	525	X	0.16	0.17	0.10	0.03	0.03	ND	ND	ND	8
6	526		0.97	0.37	0.12	0.18	ND	ND	ND	ND	7
6	527		0.36	0.46	0.39	ND	0.12	ND	ND	ND	6
6	528		NA	NA	NA	NA	NA	NA	NA	NA	4
6	529		0.24	0.37	0.24	0.02	ND	ND	ND	ND	3
6	530	X	0.26	0.13	ND	ND	ND	ND	ND	ND	2
6	530	X	0.38	0.42	0.26	ND	0.03	ND	ND	ND	3
6	531		0.36	0.29	0.24	ND	ND	ND	ND	ND	1
6	532		0.24	0.28	0.27	0.05	ND	ND	ND	ND	8
6	533		1.03	0.36	0.22	0.12	ND	ND	ND	ND	7
6	534	X	QCF	QCF	QCF	QCF	ND	ND	ND	ND	2
6	534	X	0.32	0.12	QCF	QCF	0.02	ND	ND	ND	2
6	534	X	0.17	0.33	0.31	ND	0.05	ND	ND	ND	6
6	535		QCF	QCF	QCF	QCF	ND	ND	ND	ND	4

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SAS
TABLE I-1
SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
6	536		0.16	0.04	ND	ND	ND	ND	ND	ND	3
6	537		0.29	0.45	0.35	ND	ND	ND	ND	ND	2
6	538		0.25	0.14	0.08	0.10	0.03	ND	ND	ND	1
6	539		0.62	0.37	0.34	0.15	ND	ND	ND	ND	7
6	540		0.21	0.47	0.51	0.04	0.19	ND	ND	ND	6
6	541		QCF	QCF	QCF	QCF	ND	ND	ND	ND	4
6	542		0.36	0.88	0.70	ND	0.09	ND	ND	ND	3
6	543		0.53	1.49	1.18	0.14	1.22	0.25	0.85	0.30	2
6	544		0.64	3.51	2.90	0.15	1.99	0.97	3.15	0.47	1
6	545		0.38	0.89	1.08	0.10	0.48	ND	ND	ND	8
6	546		0.87	0.48	0.32	0.18	ND	ND	ND	ND	7
6	547		0.22	0.71	0.68	ND	0.38	ND	ND	ND	6
6	548		QCF	QCF	QCF	QCF	QCF	ND	ND	ND	4
6	549		0.52	0.86	0.68	0.10	0.56	ND	ND	ND	3
6	550		0.55	0.26	ND	0.09	0.20	ND	ND	ND	2
6	551		0.50	0.85	0.72	0.11	0.52	ND	0.34	0.22	1
6	552		0.42	0.51	0.53	0.15	0.23	ND	ND	0.13	8
6	553		1.51	0.37	0.22	0.19	ND	ND	ND	0.56	7
6	554		0.22	0.59	0.58	0.04	0.24	ND	ND	0.08	6
6	555		NA	NA	NA	NA	NA	NA	NA	NA	4
6	556		0.39	0.49	0.29	ND	0.06	0.19	ND	ND	3
6	557		QCF	QCF	QCF	QCF	ND	ND	ND	ND	2
6	558		0.42	1.00	1.22	0.10	0.53	0.09	0.26	0.05	1
6	559		0.91	0.36	0.21	0.12	ND	ND	ND	ND	7
6	560		0.24	0.34	0.25	0.05	0.13	ND	ND	ND	6
6	561		NA	NA	NA	NA	NA	NA	NA	NA	4
6	562		0.45	1.09	0.90	0.09	0.28	ND	ND	ND	3
6	563		QCF	0.44	0.35	0.08	0.28	ND	0.31	ND	2
6	564		0.39	0.47	0.50	0.08	0.28	ND	0.20	0.07	1
6	565		0.26	0.79	1.27	0.07	0.13	0.03	ND	ND	8
6	566		0.69	0.33	0.28	ND	ND	ND	ND	ND	7
6	567		0.24	0.32	0.18	ND	ND	ND	ND	ND	6
6	568		NA	NA	NA	NA	NA	NA	NA	NA	4
6	569		0.45	1.22	1.00	0.09	0.45	ND	ND	ND	3
6	570		QCF	0.39	0.29	ND	0.22	ND	ND	ND	2
6	571		QCF	0.22	0.19	0.11	0.06	ND	ND	ND	1
6	572		0.28	0.35	0.38	0.08	0.14	ND	ND	ND	8
6	573		1.14	0.40	0.39	0.10	ND	ND	ND	ND	7

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
6	574		0.27	0.32	0.35	ND	0.05	ND	ND	ND	6
6	576		0.31	0.30	0.25	0.07	0.04	ND	ND	ND	3
6	577		0.64	0.19	0.12	0.05	ND	ND	ND	ND	2
6	578		QCF	0.21	0.16	0.08	0.11	ND	QCF	ND	1
6	579		0.69	0.30	0.14	0.08	ND	ND	ND	ND	7
6	580		0.25	0.39	0.44	ND	0.18	0.11	0.27	0.28	6
6	581		NA	NA	NA	NA	NA	NA	NA	NA	4
6	582		0.37	0.46	0.20	ND	ND	ND	ND	ND	3
6	582		QCF	QCF	QCF	ND	QCF	ND	ND	QCF	3
6	583		0.64	0.16	0.10	0.08	0.09	ND	ND	ND	2
6	584		0.42	0.56	0.54	0.10	0.18	ND	ND	0.11	1
6	585		0.32	0.36	0.27	0.11	0.17	ND	ND	ND	8
6	586		0.65	0.41	0.25	ND	0.18	ND	0.22	ND	7
6	587		0.85	0.15	0.11	0.03	ND	ND	ND	ND	6
6	588		NA	NA	NA	NA	NA	NA	NA	NA	4
6	937		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
6	938		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
6	939		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
6	940		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
6	941		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
6	942		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
6	974		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
6	976		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
6	492R		0.29	0.78	0.90	ND	0.49	0.24	0.47	0.20	6
7	446		NA	NA	NA	NA	NA	NA	NA	NA	4
7	447		0.41	0.45	0.30	ND	0.17	ND	ND	ND	3
7	448		0.34	0.59	1.24	ND	0.14	ND	ND	ND	2
7	449		0.43	1.31	1.25	0.08	0.26	ND	0.38	0.12	1
7	450		0.34	QCF	0.29	0.10	0.13	ND	0.18	ND	8
7	451		0.94	0.63	0.64	0.13	0.25	ND	0.19	ND	7
7	452		0.38	0.56	1.11	ND	0.15	ND	ND	ND	6
7	453		NA	NA	NA	NA	NA	NA	NA	NA	4
7	454		0.32	0.48	0.36	ND	0.13	ND	ND	ND	3
7	455		0.31	0.33	0.28	ND	0.14	ND	ND	ND	2
7	456		0.41	0.95	0.79	0.06	0.15	ND	ND	0.05	1
7	457	X	0.62	0.25	0.26	0.08	0.05	ND	ND	ND	1
7	457	X	0.20	0.39	0.38	0.04	0.10	ND	ND	ND	8
7	458		0.76	0.64	QCF	ND	0.16	ND	ND	ND	7

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
7	459		0.45	1.15	1.10	0.02	ND	ND	ND	ND	6
7	460		NA	NA	NA	NA	NA	NA	NA	NA	4
7	461		QCF	QCF	QCF	ND	QCF	ND	ND	QCF	3
7	462	X	QCF	QCF	QCF	QCF	QCF	ND	ND	ND	2
7	462	X	0.42	1.10	1.21	0.05	0.34	ND	ND	ND	6
7	462	X	0.54	1.36	1.22	ND	0.43	ND	0.26	ND	6
7	463		0.48	0.59	0.60	ND	ND	ND	ND	ND	1
7	464		0.86	4.49	3.06	0.12	0.49	ND	ND	ND	8
7	465		0.56	0.59	0.67	ND	0.14	ND	0.32	ND	7
7	466		0.43	0.86	0.99	0.06	0.21	ND	ND	ND	6
7	467	X	NA	NA	NA	NA	NA	NA	NA	NA	4
7	467	X	0.41	0.17	0.07	0.05	ND	ND	ND	ND	2
7	468	X	0.31	0.80	0.84	0.08	ND	0.15	0.59	ND	8
7	468	X	QCF	QCF	QCF	ND	QCF	QCF	ND	ND	3
7	469		0.38	0.30	0.10	ND	0.05	ND	ND	ND	2
7	470		0.73	3.52	2.63	ND	0.89	ND	2.01	ND	1
7	471		0.72	0.93	0.98	0.09	0.19	ND	0.76	ND	7
7	472	X	0.45	0.65	0.53	ND	ND	ND	ND	ND	2
7	472	X	0.38	0.51	0.44	ND	0.10	ND	ND	ND	6
7	473	X	NA	NA	NA	NA	NA	NA	NA	NA	4
7	473	X	0.37	0.80	0.72	0.04	ND	ND	ND	ND	6
7	474		0.23	0.21	0.11	ND	ND	ND	ND	ND	3
7	475		0.39	0.27	0.26	ND	ND	ND	ND	ND	2
7	476	X	0.63	0.44	0.42	0.11	0.14	ND	0.35	ND	1
7	476	X	QCF	QCF	QCF	ND	ND	ND	ND	ND	3
7	477		0.46	0.70	0.76	0.09	0.21	ND	ND	ND	8
7	478		0.69	0.58	0.49	0.13	0.25	ND	0.16	ND	7
7	479		0.33	0.89	1.02	ND	0.21	0.12	0.14	0.07	6
7	480		NA	NA	NA	NA	NA	NA	NA	NA	4
7	575		NA	NA	NA	NA	NA	NA	NA	NA	4
7	589		0.79	3.77	3.91	0.08	2.42	ND	ND	0.61	2
7	590		0.31	0.18	0.12	0.09	0.02	ND	ND	ND	1
7	591		0.36	0.26	0.19	0.03	0.10	ND	ND	ND	8
7	592	X	QCF	QCF	QCF	QCF	ND	ND	ND	ND	7
7	592	X	0.19	0.34	0.46	ND	ND	ND	ND	ND	8
7	592	X	0.19	0.34	QCF	QCF	0.17	0.05	ND	ND	8
7	593		ND	0.22	0.25	0.02	ND	ND	ND	ND	6
7	594		NA	NA	NA	NA	NA	NA	NA	NA	4

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SAS
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RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
7	595		0.36	1.19	0.87	ND	ND	ND	ND	0.13	3
7	596		0.47	0.77	0.64	0.06	0.20	ND	ND	ND	2
7	597		0.43	0.50	0.27	0.09	0.08	ND	ND	ND	1
7	598		0.33	0.24	0.35	0.10	ND	ND	ND	ND	8
7	599		QCF	QCF	QCF	QCF	ND	ND	ND	ND	7
7	600		0.16	0.17	0.15	0.04	ND	ND	ND	ND	6
7	601		NA	NA	NA	NA	NA	NA	NA	NA	4
7	602		0.35	0.56	0.56	ND	0.14	ND	ND	ND	3
7	603		0.35	0.90	0.83	ND	0.51	ND	0.38	ND	2
7	604	X	0.41	0.24	0.20	0.10	0.07	ND	ND	ND	1
7	604	X	0.26	0.34	0.32	0.08	ND	ND	0.29	ND	3
7	605		0.29	0.25	0.20	0.07	0.12	ND	ND	ND	8
7	606		QCF	QCF	QCF	ND	QCF	ND	ND	ND	7
7	607		0.36	0.95	1.11	0.05	0.45	ND	0.43	ND	6
7	608		NA	NA	NA	NA	NA	NA	NA	NA	4
7	609		0.32	0.76	0.63	ND	0.29	ND	0.31	ND	3
7	610		0.31	0.57	0.54	0.06	0.23	ND	0.25	ND	2
7	611		0.28	0.42	0.31	0.07	0.12	ND	ND	ND	1
7	612		0.79	0.67	0.47	0.16	ND	ND	ND	ND	7
7	613		QCF	QCF	QCF	ND	QCF	ND	ND	QCF	6
7	614		NA	NA	NA	NA	NA	NA	NA	NA	4
7	615		0.44	1.15	0.86	0.10	ND	ND	ND	ND	3
7	616		QCF	QCF	QCF	QCF	QCF	QCF	QCF	QCF	2
7	617		QCF	0.31	0.36	0.08	0.17	ND	QCF	ND	1
7	618		0.33	0.34	0.37	0.12	0.13	ND	ND	ND	8
7	619		0.86	0.47	0.30	0.18	ND	ND	ND	ND	7
7	620		0.31	0.78	1.05	0.04	0.18	ND	ND	0.08	6
7	621		NA	NA	NA	NA	NA	NA	NA	NA	4
7	622		QCF	QCF	QCF	ND	QCF	ND	QCF	QCF	3
7	623		0.44	0.37	0.43	QCF	0.36	ND	0.60	ND	2
7	624		QCF	0.65	0.62	0.12	0.15	ND	QCF	0.04	1
7	625		0.46	1.14	1.18	0.11	0.33	ND	ND	ND	8
7	626		0.86	1.43	0.78	0.14	0.56	ND	1.11	ND	7
7	627		0.37	1.33	1.65	ND	0.52	0.15	QCF	0.26	6
7	628		NA	NA	NA	NA	NA	NA	NA	NA	4
7	629		0.34	1.02	1.21	0.06	0.23	ND	0.51	ND	3
7	630		QCF	QCF	QCF	QCF	QCF	ND	ND	ND	2
7	631		0.47	0.81	0.71	0.13	0.46	0.12	0.29	0.12	1

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SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
7	632		0.62	0.71	0.90	ND	0.26	ND	0.35	ND	7
7	633		0.24	0.33	0.38	ND	0.11	ND	ND	ND	6
7	634		NA	NA	NA	NA	NA	NA	NA	NA	4
7	635		0.54	1.79	1.31	0.10	0.28	ND	0.21	ND	3
7	636		QCF	QCF	QCF	QCF	QCF	ND	QCF	QCF	2
7	637		0.47	0.75	0.54	0.15	0.21	ND	ND	0.04	1
7	638		0.23	0.23	0.17	0.05	0.05	ND	ND	0.12	8
7	639		0.60	0.33	0.29	0.04	ND	ND	0.10	ND	7
7	640		0.31	0.64	0.44	0.02	0.27	0.11	QCF	0.07	6
7	641		NA	NA	NA	NA	NA	NA	NA	NA	4
7	642		0.50	1.92	1.65	ND	ND	1.25	1.92	ND	3
7	643		0.59	1.15	0.57	0.13	ND	ND	ND	ND	2
7	644		0.91	4.04	1.61	0.17	1.69	0.23	1.24	0.40	1
7	645		0.20	0.21	0.22	0.05	ND	ND	ND	ND	8
7	646		0.91	0.64	0.51	QCF	0.23	ND	0.40	ND	7
7	647		0.29	0.39	0.51	0.03	0.06	ND	0.05	ND	6
7	648		0.21	0.18	0.17	ND	ND	ND	ND	ND	4
7	649		0.27	1.12	0.65	0.04	0.22	ND	0.28	0.09	3
7	650		0.53	0.42	0.27	0.10	0.09	ND	ND	ND	2
7	651		0.34	0.52	0.37	0.11	0.11	ND	0.07	0.05	1
7	652		0.68	0.37	0.30	ND	ND	ND	ND	ND	7
7	653		0.35	1.20	1.17	0.05	0.30	0.34	ND	0.22	6
7	654		0.31	0.36	0.43	0.09	ND	ND	ND	ND	4
7	655		0.23	0.51	0.60	ND	0.23	ND	ND	ND	3
7	656		0.56	0.40	0.22	0.12	0.12	ND	ND	ND	2
7	657		0.37	0.29	0.31	0.10	0.09	ND	0.08	ND	1
7	658		0.73	0.30	0.31	QCF	0.05	ND	ND	ND	8
7	659		QCF	QCF	QCF	ND	ND	ND	QCF	ND	7
7	660		0.30	0.52	0.53	0.05	0.16	0.05	0.16	ND	6
7	661		0.21	0.15	0.12	0.06	ND	ND	ND	ND	4
7	662		0.70	2.30	2.64	ND	1.00	0.98	0.84	0.36	3
7	663		0.65	0.99	0.61	ND	0.81	ND	0.95	0.35	2
7	664		QCF	1.73	2.86	0.13	1.00	0.76	1.74	0.34	1
7	665		0.69	0.54	1.03	QCF	0.36	0.18	0.43	0.16	8
7	666		0.52	0.41	0.43	0.10	ND	ND	ND	ND	7
7	667		0.40	1.06	1.20	0.06	0.26	0.22	0.27	0.09	6
7	668		QCF	QCF	QCF	QCF	ND	ND	QCF	ND	4
7	669		0.46	0.95	1.73	QCF	0.47	ND	ND	ND	3

LEGEND:

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
7	932		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
7	933		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
7	934		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
7	935		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
7	936		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
7	973		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
7	975		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
8	745		0.26	0.15	0.07	0.06	ND	ND	ND	ND	2
8	746		0.37	0.13	0.05	0.08	ND	ND	ND	QCF	1
8	747		0.20	0.07	ND	0.07	ND	ND	ND	ND	8
8	748		1.01	0.31	0.08	0.21	ND	ND	ND	ND	7
8	749		0.52	0.13	0.03	0.06	ND	ND	ND	ND	6
8	750	X	0.29	0.09	0.02	0.04	ND	ND	ND	ND	1
8	750	X	0.85	0.24	0.06	0.10	ND	ND	ND	ND	7
8	751		0.30	0.20	ND	ND	ND	ND	ND	ND	3
8	752		NT	NT	NT	NT	NT	NT	NT	NT	
8	753		0.33	0.14	0.04	ND	ND	ND	ND	ND	6
8	754	X	0.38	0.09	0.02	0.06	ND	ND	ND	ND	1
8	754	X	0.11	0.09	0.04	ND	ND	ND	ND	ND	8
8	755		0.85	0.14	ND	ND	ND	ND	ND	ND	7
8	756		0.44	0.12	0.03	0.05	ND	ND	ND	ND	6
8	757		NA	NA	NA	NA	NA	NA	NA	NA	4
8	758		QCF	QCF	QCF	ND	ND	ND	ND	ND	3
8	759		0.92	0.25	0.05	0.06	ND	ND	ND	ND	2
8	760		0.27	0.09	ND	0.07	ND	ND	ND	ND	1
8	761		0.12	0.07	ND	0.03	ND	ND	ND	ND	8
8	762		0.85	0.15	0.03	0.06	ND	ND	ND	ND	7
8	763		0.35	0.25	0.18	0.02	ND	ND	ND	ND	6
8	764		NA	NA	NA	NA	NA	NA	NA	NA	4
8	765		QCF	QCF	QCF	ND	ND	QCF	ND	ND	7
8	766	X	0.29	0.15	0.03	0.07	ND	ND	ND	ND	1
8	766	X	0.35	0.18	ND	ND	ND	ND	ND	ND	2
8	767		0.42	0.11	0.03	0.09	0.01	ND	ND	ND	1
8	768	X	0.60	0.12	0.03	0.07	ND	ND	ND	ND	7
8	768	X	QCF	QCF	QCF	ND	ND	ND	ND	QCF	3
8	769		0.55	0.15	0.04	0.04	0.09	ND	ND	ND	6
8	770	X	NA	NA	NA	NA	NA	NA	NA	NA	4
8	770	X	0.27	0.40	0.05	ND	ND	ND	ND	ND	2

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
8	771		0.18	0.15	0.04	ND	ND	ND	ND	ND	3
8	772		0.30	0.19	0.08	ND	ND	ND	ND	ND	2
8	773		0.42	0.13	0.05	0.09	ND	ND	ND	0[illegible]	1
8	774	X	0.23	0.08	0.03	ND	ND	ND	ND	ND	2
8	774	X	0.11	0.08	ND	ND	ND	ND	ND	ND	8
8	775		0.72	0.16	0.04	ND	ND	ND	ND	ND	7
8	776		0.21	0.08	0.03	ND	ND	ND	ND	ND	6
8	777	X	NA	NA	NA	NA	NA	NA	NA	NA	4
8	777	X	0.33	0.08	0.07	0.07	ND	ND	0.12	2.54	1
8	778		0.18	0.11	ND	ND	ND	ND	ND	ND	3
8	779		0.20	0.17	0.07	0.03	ND	ND	ND	ND	6
8	780	X	0.38	0.10	0.02	0.08	ND	ND	5.36	ND	1
8	780	X	0.21	0.10	0.02	ND	ND	ND	ND	ND	3
8	781	X	0.22	0.15	0.07	ND	ND	ND	ND	ND	6
8	781	X	0.32	0.15	0.05	0.09	ND	ND	ND	ND	8
8	782		0.95	0.20	0.10	0.13	ND	ND	ND	ND	7
8	783		0.16	0.08	0.05	0.01	ND	ND	ND	ND	6
8	784		NA	NA	NA	NA	NA	NA	NA	NA	4
8	785		0.32	ND	0.14	ND	ND	ND	ND	ND	3
8	786		0.21	0.11	0.07	ND	ND	ND	ND	ND	2
8	787		0.35	0.14	0.07	0.08	ND	ND	ND	ND	1
8	788		1.02	0.30	0.14	ND	ND	ND	ND	ND	7
8	789		0.17	0.09	0.08	0.04	ND	ND	ND	ND	6
8	790		NA	NA	NA	NA	NA	NA	NA	NA	4
8	791		1.38	0.27	0.10	ND	ND	ND	ND	ND	3
8	792		0.24	0.16	0.11	ND	ND	ND	ND	ND	2
8	793		0.36	0.10	0.07	0.12	ND	ND	ND	ND	1
8	794		0.22	0.09	0.06	ND	ND	ND	ND	ND	8
8	795		0.75	0.24	0.11	ND	ND	ND	ND	ND	7
8	796		0.44	0.16	0.07	ND	ND	ND	ND	ND	6
8	797		QCF	QCF	ND	ND	ND	ND	ND	ND	4
8	798		0.18	0.11	0.05	0.03	ND	ND	ND	ND	3
8	799		0.53	0.29	0.11	ND	ND	ND	ND	ND	2
8	800	X	0.37	0.12	0.05	0.14	ND	ND	ND	ND	1
8	800	X	0.46	0.17	0.05	0.09	ND	ND	ND	ND	2
8	801		0.25	0.13	0.05	0.10	ND	ND	ND	ND	8
8	802		0.56	0.11	ND	ND	ND	ND	ND	ND	7
8	803		0.38	0.92	0.84	ND	0.17	ND	0.36	ND	6

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
8	804		QCF	QCF	QCF	QCF	ND	ND	ND	ND	4
8	805		0.99	0.61	0.27	ND	ND	ND	ND	ND	3
8	806		QCF	0.12	0.04	0.05	ND	ND	ND	ND	2
8	807		QCF	0.14	0.05	ND	ND	ND	ND	ND	1
8	808		0.74	0.20	0.07	QCF	ND	ND	ND	ND	7
8	809		0.36	0.11	ND	ND	ND	ND	ND	ND	6
8	810		QCF	QCF	QCF	QCF	ND	ND	ND	ND	4
8	811		0.31	0.08	ND	ND	ND	ND	ND	ND	3
8	812		QCF	0.11	0.07	0.04	ND	ND	ND	ND	2
8	813		QCF	0.12	0.04	0.10	ND	ND	ND	ND	1
8	814		0.38	0.09	ND	QCF	ND	ND	ND	ND	8
8	815		0.67	0.16	0.06	0.08	ND	ND	ND	ND	7
8	816		0.23	0.12	ND	ND	ND	ND	ND	ND	6
8	817		NA	NA	NA	NA	NA	NA	NA	NA	4
8	818		0.33	0.28	0.13	ND	ND	ND	ND	ND	3
8	819		QCF	QCF	ND	ND	ND	ND	ND	ND	2
8	949		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
8	950		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
8	951		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
9	670		0.53	0.70	0.69	0.09	0.14	ND	0.13	ND	1
9	671		0.32	0.37	0.28	0.12	ND	ND	ND	ND	8
9	672		0.58	0.64	0.42	0.07	0.23	ND	ND	0.20	7
9	673		0.33	0.87	0.81	0.06	0.18	ND	ND	ND	6
9	674		NA	NA	NA	NA	NA	NA	NA	NA	4
9	675	X	0.34	0.45	QCF	QCF	0.08	ND	ND	ND	8
9	675	X	0.33	QCF	QCF	QCF	0.10	ND	ND	ND	8
9	675	X	QCF	QCF	QCF	ND	QCF	ND	ND	ND	3
9	678		0.23	0.42	0.35	0.06	ND	ND	ND	ND	8
9	679		QCF	QCF	QCF	ND	QCF	ND	ND	ND	7
9	680		0.32	0.98	0.74	0.03	0.28	ND	ND	ND	6
9	681		NA	NA	NA	NA	NA	NA	NA	NA	4
9	682		1.15	3.12	1.33	ND	0.78	ND	ND	ND	3
9	684		0.71	0.97	0.89	0.10	0.61	ND	ND	ND	1
9	685		0.41	0.65	0.76	0.08	ND	ND	ND	ND	8
9	686		0.73	0.70	0.60	0.07	0.27	ND	ND	ND	7
9	687		0.41	0.99	1.11	0.05	0.44	ND	ND	ND	6
9	688		0.29	0.44	0.57	0.11	1.19	0.94	0.79	0.37	4
9	689		0.40	0.57	0.54	ND	0.30	ND	0.40	ND	3

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TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
9	690	X	0.64	0.56	1.25	0.09	0.81	ND	ND	0.73	1
9	690	X	0.36	1.03	0.99	ND	0.30	ND	ND	ND	6
9	691		0.59	0.58	0.43	0.10	0.21	ND	0.15	ND	1
9	692		QCF	QCF	QCF	QCF	QCF	ND	ND	ND	7
9	695		NA	NA	NA	NA	NA	NA	NA	NA	4
9	696		0.32	0.81	0.56	ND	0.35	ND	ND	ND	2
9	698	X	0.29	0.48	0.50	ND	0.11	0.04	0.81	ND	8
9	698	X	QCF	QCF	QCF	ND	QCF	ND	QCF	ND	3
9	699		QCF	QCF	QCF	QCF	ND	ND	ND	ND	7
9	700	X	0.38	0.53	0.37	0.09	ND	ND	ND	ND	1
9	700	X	0.29	0.62	0.46	ND	ND	ND	0.11	ND	6
9	701		NA	NA	NA	NA	NA	NA	NA	NA	4
9	702		0.38	1.25	0.82	0.05	0.29	ND	ND	ND	3
9	703		0.40	0.83	0.56	ND	ND	ND	ND	ND	2
9	704		0.19	0.46	0.38	ND	0.10	ND	ND	ND	8
9	705		0.19	0.25	0.28	0.09	0.06	ND	ND	ND	8
9	706		1.09	1.40	0.79	0.08	0.38	ND	0.16	ND	7
9	707		0.30	0.60	0.51	ND	0.33	ND	0.56	ND	6
9	709	X	QCF	0.72	0.69	0.06	0.23	ND	0.83	0.08	1
9	709	X	0.50	1.03	0.56	ND	0.27	ND	1.03	ND	3
9	710		0.34	0.74	0.57	ND	0.21	ND	ND	ND	2
9	711	X	NA	NA	NA	NA	NA	NA	NA	NA	4
9	711	X	QCF	1.03	0.64	0.06	0.25	ND	ND	0.06	1
9	713	X	0.37	1.06	0.91	ND	0.60	ND	0.38	0.14	6
9	713	X	0.57	1.81	1.37	ND	0.45	0.25	ND	0.09	3
9	714	X	NA	NA	NA	NA	NA	NA	NA	NA	4
9	714	X	QCF	0.37	0.24	0.06	0.09	ND	ND	ND	1
9	715		0.40	0.91	0.84	0.09	0.08	ND	ND	ND	3
9	716		0.37	0.64	0.72	ND	ND	ND	ND	ND	2
9	717		QCF	0.53	0.50	0.11	0.19	ND	ND	0.04	1
9	718		0.43	0.76	0.62	0.17	0.18	ND	ND	0.48	8
9	719		0.88	0.38	0.22	0.16	ND	ND	ND	ND	7
9	720		0.19	0.38	0.39	ND	0.18	ND	ND	ND	6
9	721		NA	NA	NA	NA	NA	NA	NA	NA	4
9	722		0.33	0.39	0.34	ND	0.06	ND	ND	ND	3
9	723		0.33	0.63	0.48	0.05	ND	ND	ND	ND	3
9	724		0.39	0.48	0.27	0.08	0.10	ND	ND	ND	1
9	725		0.39	0.46	0.29	0.11	0.08	ND	ND	ND	8

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9	726		0.70	0.56	0.42	0.13	ND	ND	ND	ND	7
9	727		0.22	0.35	0.33	0.05	0.20	ND	ND	ND	6
9	728		NA	NA	NA	NA	NA	NA	NA	NA	4
9	729		0.39	0.69	0.50	0.09	0.33	ND	ND	ND	3
9	730		NA	NA	NA	NA	NA	NA	NA	NA	2
9	731		1.03	1.03	0.84	0.09	0.13	0.08	QCF	ND	1
9	732		0.48	0.37	0.23	0.05	0.06	ND	ND	ND	7
9	733		QCF	QCF	QCF	ND	QCF	ND	QCF	ND	6
9	734		NA	NA	NA	NA	NA	NA	NA	NA	4
9	735		0.40	1.04	0.67	ND	0.17	ND	0.08	ND	3
9	736		QCF	QCF	QCF	QCF	ND	ND	ND	ND	2
9	737		NA	NA	NA	NA	NA	NA	NA	NA	1
9	738		0.34	0.32	0.26	0.22	0.09	ND	ND	0.50	8
9	739		0.82	0.68	0.46	0.15	ND	ND	ND	ND	7
9	740		QCF	QCF	QCF	ND	QCF	ND	ND	ND	6
9	741		NA	NA	NA	NA	NA	NA	NA	NA	4
9	742		0.19	0.52	0.45	ND	ND	ND	ND	ND	3
9	743		0.54	0.70	0.52	0.11	0.25	ND	ND	ND	2
9	744		QCF	0.68	0.47	0.12	0.18	ND	0.07	0.30	1
9	952		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
9	953		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
9	954		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
9	694R		QCF	QCF	QCF	QCF	ND	ND	ND	ND	4
9	712R		QCF	QCF	QCF	QCF	QCF	ND	ND	ND	7
9	683R		0.47	0.39	0.24	0.09	0.20	ND	ND	ND	2
9	708R		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	4
9	697R		0.45	2.91	1.20	ND	0.29	ND	0.37	80.81	1
9	693R		0.56	1.17	1.14	0.05	0.33	0.30	0.44	ND	6
9			NT	NT	NT	NT	NT	NT	NT	NT	
9			NT	NT	NT	NT	NT	NT	NT	NT	
10	820		0.28	0.23	0.15	0.08	ND	ND	ND	ND	3
10	821		0.36	0.36	0.30	ND	0.12	ND	ND	ND	2
10	822	X	0.66	1.72	1.39	0.12	1.10	0.27	0.54	0.23	1
10	822	X	0.54	1.41	1.20	0.06	0.79	ND	0.52	0.12	1
10	823		0.49	0.37	0.37	0.19	ND	ND	ND	ND	8
10	824		0.73	0.26	0.31	ND	ND	ND	0.13	ND	7
10	825		QCF	QCF	QCF	ND	QCF	ND	QCF	QCF	6
10	826		NA	NA	NA	NA	NA	NA	NA	NA	4

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
10	827	X	0.43	1.59	2.41	ND	0.51	ND	ND	ND	6
10	827	X	0.69	2.23	2.68	ND	0.62	ND	0.67	ND	3
10	828		0.48	1.77	1.07	0.10	0.33	ND	ND	ND	2
10	829		0.27	0.33	0.24	0.07	0.06	ND	ND	ND	1
10	830		0.20	0.41	0.38	0.06	ND	ND	0.29	ND	8
10	831		0.57	0.19	0.08	0.14	ND	ND	ND	ND	7
10	832		0.36	0.83	0.82	0.07	0.19	ND	0.70	ND	6
10	834		QCF	QCF	QCF	ND	QCF	QCF	QCF	QCF	3
10	835		0.30	1.34	1.67	0.08	0.79	ND	0.69	0.20	2
10	836		0.84	3.93	4.07	0.11	3.14	0.43	0.82	3.23	1
10	837		0.43	1.12	21.02	0.10	2.49	0.49	1.75	1.55	8
10	838		0.69	0.37	0.61	0.04	ND	ND	ND	ND	7
10	839		0.18	0.25	0.21	ND	0.06	ND	ND	0.04	6
10	840		NA	NA	NA	NA	NA	NA	NA	NA	4
10	841		0.43	2.89	2.47	ND	10.88	ND	5.16	0.23	3
10	841		QCF	QCF	QCF	ND	QCF	QCF	QCF	QCF	3
10	842		0.23	0.24	0.21	0.09	ND	ND	ND	ND	2
10	843		0.42	0.17	0.12	0.06	0.08	ND	0.07	ND	1
10	844		0.72	0.56	0.71	ND	ND	ND	0.40	0.12	7
10	845		0.45	0.88	0.92	0.09	0.15	ND	ND	ND	6
10	846		NA	NA	NA	NA	NA	NA	NA	NA	4
10	847		QCF	QCF	QCF	ND	QCF	ND	ND	QCF	3
10	848		0.43	0.73	0.54	0.07	2.28	ND	2.32	ND	2
10	849		0.49	0.58	0.37	0.12	0.15	ND	0.12	ND	1
10	850	X	NA	NA	NA	NA	NA	NA	NA	NA	4
10	850	X	0.26	0.12	0.23	ND	0.05	ND	ND	ND	8
10	851	X	0.35	0.54	0.44	0.08	0.08	ND	0.06	0.04	1
10	851	X	0.53	0.40	0.35	0.09	ND	ND	ND	ND	7
10	852	X	NA	NA	NA	NA	NA	NA	NA	NA	4
10	852	X	0.35	0.62	0.52	ND	0.11	ND	ND	ND	6
10	853		NA	NA	NA	NA	NA	NA	NA	NA	4
10	854	X	NA	NA	NA	NA	NA	NA	NA	NA	3
10	854	X	0.23	0.28	0.27	0.04	0.03	ND	ND	ND	2
10	855		0.34	0.57	0.57	0.06	0.67	ND	0.29	ND	2
10	856		0.83	2.89	1.72	0.08	0.61	0.17	0.43	0.27	1
10	857		0.27	1.00	0.92	0.10	0.85	ND	46.95	ND	8
10	858		0.54	0.20	0.13	0.11	0.33	ND	ND	ND	7
10	859		0.38	0.86	0.64	0.04	0.83	0.07	1.06	0.13	6

LEGEND:

QCF = SAMPLE ANALYSED BUT FAILED QC CRITERIA
NAC = NOT ANALYSED - CONTINGENCY SAMPLE
ND = SAMPLE ANALYSED,ANALYTE NOT DETECTED
NA = SAMPLE NOT ANALYSED
NT = SAMPLE NOT TAKEN/COLLECTED

SAS

TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
10	860		0.20	0.40	QCF	0.07	ND	ND	0.38	0.03	4
10	862		0.25	0.25	0.19	ND	0.21	ND	ND	ND	2
10	863		0.96	3.23	12.51	0.09	2.92	ND	ND	1.77	1
10	864		QCF	QCF	QCF	QCF	QCF	ND	QCF	ND	7
10	865		0.56	0.91	0.97	0.06	0.41	ND	0.33	ND	6
10	866		QCF	QCF	QCF	QCF	ND	QCF	QCF	QCF	4
10	867		0.30	0.69	1.37	ND	ND	ND	0.20	ND	3
10	868		0.37	0.33	0.39	0.11	0.16	ND	ND	ND	2
10	869		0.35	0.59	0.70	0.12	0.62	0.27	0.14	0.58	1
10	870		1.40	33.07	64.25	0.32	33.97	5.40	50.57	15.83	8
10	871		0.55	0.43	0.79	0.14	0.09	ND	ND	ND	7
10	872		0.29	2.10	2.10	ND	0.52	0.51	0.70	0.54	6
10	873		QCF	QCF	QCF	QCF	ND	ND	ND	ND	4
10	874		0.34	0.76	0.79	0.07	ND	ND	ND	ND	3
10	875		1.07	2.37	2.31	0.09	1.07	ND	0.99	0.28	2
10	876		0.23	0.17	0.12	0.08	0.02	ND	0.01	ND	1
10	877		0.32	1.20	2.81	0.07	0.39	0.15	ND	0.37	8
10	878		0.65	0.65	0.33	0.12	0.14	ND	ND	ND	7
10	879		0.22	0.70	0.83	ND	0.26	ND	ND	0.14	6
10	880	X	NA	NA	NA	NA	NA	NA	NA	NA	4
10	880	X	0.63	0.39	0.40	0.07	0.35	ND	QCF	ND	2
10	861		0.28	0.44	0.56	0.05	0.13	ND	ND	ND	3
10	882		0.63	0.38	0.39	0.06	0.10	ND	ND	0.04	2
10	883		QCF	0.20	0.21	0.10	ND	ND	ND	ND	1
10	884		0.84	0.35	0.25	ND	ND	ND	ND	ND	7
10	885		0.27	0.21	0.14	ND	ND	ND	ND	ND	6
10	886		NA	NA	NA	NA	NA	NA	NA	NA	4
10	887		0.51	1.13	1.23	0.08	0.03	ND	ND	ND	3
10	888		0.66	0.13	0.06	0.08	ND	ND	ND	ND	2
10	889		QCF	0.16	0.12	0.11	0.03	ND	ND	ND	1
10	890		0.23	2.20	0.96	0.05	ND	ND	ND	ND	8
10	891		0.77	0.92	0.39	0.11	ND	ND	ND	ND	7
10	892		1.13	QCF	6.61	ND	0.26	ND	0.19	ND	6
10	892		0.99	24.11	6.30	ND	ND	ND	ND	ND	6
10	893		NA	NA	NA	NA	NA	NA	NA	NA	4
10	894		0.54	2.15	0.83	ND	ND	ND	ND	ND	3
10	943		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
10	944		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	

LEGEND:

QCF = SAMPLE ANALYSED BUT FAILED QC CRITERIA
NAC = NOT ANALYSED - CONTINGENCY SAMPLE
ND = SAMPLE ANALYSED, ANALYTE NOT DETECTED
NA = SAMPLE NOT ANALYSED
NT = SAMPLE NOT TAKEN/COLLECTED

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SAS
TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

RESULTS GIVEN IN PARTS PER BILLION (PPB)

SAMPLE AREA 1-10	SITE NUMBER	SPLIT	DCB	TCB	TeCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC	LAB ID
10	945		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
10	946		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
10	947		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
10	948		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	
10	861R		0.41	0.95	0.78	ND	ND	ND	ND	ND	3
10	971		NAC	NAC	NAC	NAC	NAC	NAC	NAC	NAC	

LEGEND:

QCF = SAMPLE ANALYSED BUT FAILED QC CRITERIA
NAC = NOT ANALYSED - CONTINGENCY SAMPLE
ND = SAMPLE ANALYSED,ANALYTE NOT DETECTED
NA = SAMPLE NOT ANALYSED
NT = SAMPLE NOT TAKEN/COLLECTED

TABLE I-1

SOIL SAMPLING ANALYSIS RESULTS BY SAMPLING AREA AND SITE

LCIC LEGEND:

ABBREVIATION	COMPOUND NAME
DCB	1,2-DICHLOROBENZENE
TCB	1,2,4-TRICHLOROBENZENE
TeCB	1,2,3,4-TETRACHLOROBENZENE
CNP	2-CHLORONAPHTHALENE
A-BHC	ALPHA-BHC
D-BHC	DELTA-BHC
B-BHC	BETA-BHC
G-BHC	GAMMA-BHC

Appendix J
Summary of QA/QC Results

Appendix J
SUMMARY OF QA/QC RESULTS

INTRODUCTION

The soil assessment for indicator chemicals was designed to achieve the QA/QC objectives of precision, accuracy, representativeness, comparability, completeness, and detection limit, as specified in the sample collection and analysis QAPPs (CH2M HILL, 1987a and 1987b).

The following QA/QC measures were developed to assist in monitoring and achieving these QA/QC objectives:

- Holding times (comparability)
- Instrument calibration (accuracy, precision, sensitivity)
- EPA check standard analyses (accuracy)
- Surrogate recoveries (accuracy and precision)
- Matrix spike recoveries (accuracy)
- Matrix spike duplicate recoveries (precision)
- Field and laboratory blanks (comparability)
- Internal standard area and retention time differences (comparability)
- Blind QC sample recoveries (accuracy and precision)

The QC data generated by each participating laboratory for each sample were reviewed to provide a useful indication of data quality. The findings of this QA/QC data review are summarized in Table J-1 and are discussed in the paragraphs below.

HOLDING TIMES

All samples were initially extracted within 30 days of receipt by the laboratory and analyzed within 50 days of receipt, meeting the QAPP requirement. However, many samples had to be reanalyzed because they did not meet stringent QC criteria and thus ultimately did not meet the holding time criteria.

Table J-1
QC DATA SUMMARY

		Data Meeting QC Criteria	
QA Measure	Laboratory	Goal (%)	Achieved (Y or N)
MHB	1	90	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Surrogate Spike Recovery	1	90	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
MS Recovery (Advisory Only)	1	90	N
	2		N
	3		N
	6		N
	7		N
	8		N
MSD Precision (Advisory Only)	1	90	Y
	2		Y
	3		N
	6		Y
	7		Y
	8		N
BQC Recovery	1	90	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
EPA Check Standard Recovery	1	100	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y

Table J-1
(continued)

QA Measure	Laboratory	Data Meeting QC Criteria Goal (%)	Data Meeting QC Criteria Achieved (Y or N)
Internal Standard Area and Rt Variation	1	90	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Performance Check Standard (PC1 and PC2)	1	100	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Initial Calibration Standard	1	100	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Continuing Calibration Standard	1	100	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y
Holding Time (for original extraction and analysis only)	1	100	Y
	2		Y
	3		Y
	6		Y
	7		Y
	8		Y

INSTRUMENT CALIBRATIONS

All laboratories met the QC criteria for initial calibrations, performance check standard calibrations, and continuing calibrations. In general, this indicates a low probability of large instrument errors in the LCIC concentration estimates and increases the confidence of the reported concentrations.

EPA CHECK STANDARD ANALYSES

The recoveries of all reported EPA check standard analyses were within the required 80 to 120 percent of the theoretical concentration. Although the EPA check standard measurements do not include the variability associated with sampling, transportation, storage, preparation, and extraction of samples, the data indicate the calibration method had good accuracy and precision.

SURROGATE RECOVERIES

More than 95 percent of surrogate analyses had recoveries within the control limits as specified in the QAPP. A number of the recoveries exceeded the control limits because of dilution analysis of the sample extract. Surrogate recoveries for diluted extracts were not required to meet the control limits specified in the QAPP. Also, a number of outliers were due to not meeting the advisory upper control limit for 2,4,6-tribromobiphenyl. Having high percentages of reported surrogate recoveries within the QC criteria generally increases the confidence in both the methodology employed and in the reported concentrations.

MATRIX SPIKE/MATRIX SPIKE DUPLICATE ANALYSES

The matrix spike/matrix spike duplicate (MS/MSD) samples were analyzed to assess the accuracy and precision of the analytical method. The percent recovery and relative percent difference (RPD) control limits of the MS/MSD analysis are advisory only. This is because the results of MS/MSD analysis are dependent upon the matrix of individual samples and are not under the direct control of the laboratory. This follows the example of the EPA CLP where MS/MSD control limits are also advisory.

The percent recovery and RPD results from the MS/MSD analysis were evaluated to determine if they achieved the goal of meeting QC criteria for 90 percent of the analysis. As shown in Table J-1, none of the six laboratories used for the soil assessment achieved the recovery goal. This is probably because the stringent control limits specified in the QAPP were developed based on method validation results from only the two experienced laboratories used in the method development work. The time constraints prevented a second multi-laboratory MS/MSD study to revise the control limits. The samples were not reanalyzed because the control limits were advisory only. Four of the six laboratories did meet the 90 percent goal for MS/MSD precision. This demonstrated, in general, the reproducibility of quantification for most of the laboratories.

FIELD AND LABORATORY BLANK ANALYSES

The laboratory method/holding blank results met the 90 percent completeness goal as specified in the QAPP. The laboratory method/holding blank was required to contain no more than 0.5 µg/kg of LCICs (0.6 µg/kg for 1,2-dichlorobenzene) or LCIC interferences. Except 1,2-dichlorobenzene, all the method/holding blank results showed very low levels of blank contamination. For 1,2-dichlorobenzene, all the laboratories had about a 0.2-ppb level of contamination, with the exception of Laboratory 8, which had about 0.5 ppb. Field handling blanks were also analyzed by the laboratories. The field handling blank results generally showed slightly higher LCIC concentrations than the laboratory method/holding blanks. This was not unexpected because the field handling blanks underwent all the same steps of sample collection, extrusion, mixing, shipping, and analysis as a normal sample. Another contributing factor may be the fact that a native soil matrix is used for the field handling blank while a sand matrix is used for the laboratory method/holding blanks.

INTERNAL STANDARD AREA AND RETENTION TIME DIFFERENCES

The 90 percent completeness goal for internal standard area and retention time differences was met by all the laboratories. The retention time difference criteria were always met, but the internal standard area difference criteria were not always met. The laboratories reinjected the samples when necessary, as required by the QAPP. The internal standard area response and retention time difference observed over the course of the study did not vary significantly, thus increasing the confidence in the reported values.

BLIND QC SAMPLE ANALYSES

The blind QC sample results were generally within the control limits specified by EMSL-LV. The 90 percent data completeness goal was met by all the laboratories, except Laboratory 4, as noted in Section 6.1. In general, the laboratories performed well on the blind QC samples and no apparent concentration-related recovery bias was observed within the concentration ranges used in the blind QC samples (discussed in Appendix H).

REFERENCES

CH2M HILL. 1987a. Love Canal Habitability Study--Soil Sample Collection and Preparation Quality Assurance Project Plan (Final Revised Version).

CH2M HILL. 1987b. Love Canal Habitability Study--Soil Sample Laboratory Quality Assurance Project Plan.

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APPENDIX K
Supplementary Results for the Statistical Comparisons

Appendix K
SUPPLEMENTARY RESULTS FOR THE STATISTICAL COMPARISONS

This appendix supplements the results presented in Section 6.4. Included are the following:

- Two-sided p-values for the results presented in Tables 6-8 and 6-9 (Tables K-1 and K-2).
- Spearman's (rank) correlations between LCICs for each of the seven EDA sampling areas and the three comparison areas (Tables K-3a to K-3j).
- Results of the application of the univariate and multivariate blocked Wilcoxon test to all data that are either "good" or "uncertain" (Tables K-4 to K-8).
- Results of the application of the univariate and multivariate blocked Wilcoxon test to all "good" data with concentrations below 1 ppb treated as nondetectable (Tables K-9 to K-12).
- Results of the retrospective power simulations for the univariate and multivariate tests.

The two-sided p-values presented in Table K-1 correspond to the results of the univariate comparisons between EDA sampling areas and comparison areas reported in Table 6-8 of Section 6.4. Similarly, the p-values presented in Table K-2 correspond to the results of the multivariate comparisons reported on Table 6-9 of Section 6.4.

The Spearman's rank correlations (Conover, 1980) presented for each area in Tables K-3a to K-3j were computed by calculating the Spearman's correlation within each laboratory and then averaging these within-laboratory Spearman's correlations over all laboratories. Nondetectable values were treated as tied in the usual way. The sample size (N) reported for each area is the number of observations over all laboratories.

The Spearman's correlations should be considered as exploratory statistics; they were not used directly in the comparison method described in Section 5.5. Generally, the results show that: (1) LCICs in the chlorobenzene group (di-, tri-, and tetrachlorobenzene) are strongly correlated, (2) chloronaphthalene is relatively uncorrelated with the remaining seven LCICs, (3) alpha-BHC is relatively strongly correlated with all the remaining LCICs, and (4) there is modest correlation among the BHC group (alpha-, delta-, beta-, and gamma-BHC). Approximately 95 percent confidence bounds for a two-sided test against a null hypothesis of zero correlation are +2/N-2, so that correlations with absolute value less than about 0.3 should not be considered significant.

Tables K-4, K-5, and K-6 are analogous to Tables 6-8, 6-9, and 6-10 of Section 6.4, except that the analyses were performed with "good" and "uncertain" data, rather than just "good" data. In Tables K-4 and K-5, any changes in direction or magnitude of significance between the comparisons based on the "good" data and those based on the "good" + "uncertain" data are recorded with two sets of symbols: the second set of symbols (in parentheses) denotes the original result based on the "good" data alone. The two-sided p-values for the univariate and multivariate comparisons with the "good" + "uncertain" data are given in Tables K-7 and K-8, respectively.

Table K-9 and K-10 are analogous to Tables 6-8 and 6-10, except that an artificial detection limit of 1.0 ppb was imposed to test the sensitivity of the results to relatively "large" concentrations only. As for the previously discussed analyses based on the "good" + "uncertain" data, any change in direction or magnitude of significance between the comparisons based on the "good" data and those based on the "good" data with an artificial detection limit of 1 ppb are recorded with two sets of symbols. The two-sided p-values for the univariate comparisons for these data are given in Table K-11. No multivariate analyses were performed for this data set because the artificial 1 ppb detection limit resulted in several cases where all observations were less than the detection limit for some of the LCICs; this precluded computation of a non-singular variance-covariance matrix based on ranks.

ABBREVIATIONS

The following chemical abbreviations are used in Appendix K:

DCB	1,2 Dichlorobenzene
TCB	1,2,4 Trichlorobenzene
QCB	1,2,3,4 Tetrachlorobenzene
CNP	2 Chloronaphthalene
A-BHC	Alpha BHC
B-BHC	Beta BHC
D-BHC	Delta BHC
G-BHC	Gamma BHC

REFERENCE

Conover, W.J. 1980. Practical Nonparametric Statistics. John Wiley & Sons, New York, New York.

Table K-1

TWO-SIDED p-VALUES FOR THE UNIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD

LCIC	Comparison Area	EDA Sampling Areas							Comparison Areas		
		1	2	3	4	5	6	7	221	225	C&T
DCB	221	0.000	0.805	0.980	0.003	0.617	0.009	0.992	1.000	0.757	0.007
	225	0.000	0.539	0.583	0.025	0.779	0.312	0.556	0.757	1.000	0.194
	C&T	0.000	0.008	0.002	0.915	0.058	0.146	0.022	0.007	0.194	1.000
TCB	221	0.000	0.001	0.014	0.011	0.268	0.000	0.123	1.000	0.368	0.000
	225	0.000	0.010	0.032	0.077	0.828	0.005	0.808	0.368	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
QCB	221	0.000	0.000	0.000	0.040	0.446	0.000	0.446	1.000	0.346	0.000
	225	0.000	0.000	0.005	0.054	0.250	0.000	0.982	0.346	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
CNP	221	0.110	0.055	0.059	0.597	0.311	0.383	0.965	1.000	0.824	0.091
	225	0.047	0.013	0.005	0.107	0.018	0.322	0.762	0.824	1.000	0.010
	C&T	0.693	0.914	0.814	0.103	0.605	0.193	0.018	0.091	0.010	1.000
A-BHC	221	0.000	0.000	0.069	0.630	0.270	0.028	0.509	1.000	0.346	0.000
	225	0.000	0.001	0.207	0.410	0.942	0.192	0.577	0.346	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
D-BHC	221	0.000	0.000	0.000	0.032	0.015	0.563	0.206	1.000	0.075	0.070
	225	0.000	0.000	0.150	0.573	0.560	0.372	0.667	0.075	1.000	0.001
	C&T	0.000	0.000	0.000	0.000	0.000	0.008	0.002	0.070	0.001	1.000
B-BHC	221	0.000	0.000	0.000	0.016	0.453	0.247	0.072	1.000	0.033	0.000
	225	0.000	0.105	0.460	0.755	0.118	0.001	0.632	0.033	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	1.000
G-BHC	221	0.000	0.000	0.001	0.020	0.278	0.921	0.457	1.000	0.095	0.007
	225	0.000	0.014	0.179	0.711	0.461	0.035	0.140	0.095	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.007	0.000	1.000

a C&T = Cheektowaga and Tonawanda
221 = Census Tract 221
225 = Census Tract 225

Table K-2

TWO-SIDED p-VALUES FOR NONPARAMETRIC MULTIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD

Comparison Area	EDA Sampling Areas							Comparison Areas		
	1	2	3	4	5	6	7	221	225	C&T
221	0.000	0.000	0.000	0.000	0.037	0.001	0.004	1.000	0.017	0.000
225	0.000	0.000	0.022	0.095	0.023	0.019	0.778	0.017	1.000	0.000
C&T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000

Table K-3a

LCIC RANK CORRELATIONS FOR EDA SAMPLING AREA 1 [a]

N = 31 [b]

LCIC	DCB	TCB	QCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC
DCB	1.00							
TCB	0.79	1.00						
QCB	0.80	0.93	1.00					
CNP	0.36	0.21	0.35	1.00				
A-BHC	0.65	0.74	0.81	0.27	1.00			
D-BHC	0.46	0.53	0.62	0.39	0.83	1.00		
B-BHC	0.52	0.70	0.67	0.21	0.84	0.62	1.00	
G-BHC	0.62	0.64	0.65	0.28	0.85	0.67	0.83	1.00

Table K-3b

LCIC RANK CORRELATIONS FOR EDA SAMPLING AREA 2 [a]

N = 60 [b]

LCIC	DCB	TCB	QCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC
DCB	1.00							
TCB	0.77	1.00						
QCB	0.72	0.94	1.00					
CNP	0.29	0.33	0.33	1.00				
A-BHC	0.60	0.77	0.80	0.34	1.00			
D-BHC	0.42	0.45	0.48	0.29	0.55	1.00		
B-BHC	0.30	0.50	0.59	0.42	0.56	0.47	1.00	
G-BHC	0.47	0.51	0.58	0.29	0.76	0.60	0.41	1.00

---

a. Correlations were computed by calculating correlations within laboratories and then averaging correlations across laboratories.

b. N denotes total sample size over all laboratories.

Table K-3c

LCIC RANK CORRELATIONS FOR EDA SAMPLING AREA 3 a

N = 62 b

LCIC								

DCB	1.00							
TCB	0.68	1.00						
QCB	0.59	0.85	1.00					
CNP	-0.02	-0.27	-0.30	1.00				
A-BHC	0.40	0.61	0.59	-0.13	1.00			
D-BHC	0.10	0.18	0.15	0.03	0.27	1.00		
B-BHC	0.42	0.51	0.43	-0.15	0.67	0.32	1.00	
G-BHC	0.27	0.37	0.30	0.01	0.34	0.11	0.41	1.00
	DCB	TCB	QCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC

Table K-3d

LCIC RANK CORRELATIONS FOR EDA SAMPLING AREA 4 a

N = 45 b

LCIC								

DCB	1.00							
TCB	0.61	1.00						
QCB	0.42	0.84	1.00					
CNP	0.12	-0.17	-0.24	1.00				
A-BHC	0.41	0.52	0.65	-0.08	1.00			
D-BHC	0.17	0.33	0.34	0.25	0.13	1.00		
B-BHC	0.10	0.31	0.45	-0.25	0.63	0.14	1.00	
G-BHC	0.17	0.34	0.37	-0.34	0.34	-0.10	0.32	1.00
	DCB	TCB	QCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC

---

a. Correlations were computed by calculating correlations within laboratories and then averaging correlations across laboratories.

b. N denotes total sample size over all laboratories.

Table K-3e

LCIC RANK CORRELATIONS FOR EDA SAMPLING AREA 5 [a]

N = 68 [b]

LCIC								
DCB	1.00							
TCB	0.73	1.00						
QCB	0.79	0.92	1.00					
CNP	0.09	-0.01	0.01	1.00				
A-BHC	0.59	0.75	0.68	0.02	1.00			
D-BHC	0.49	0.50	0.52	0.10	0.44	1.00		
B-BHC	0.63	0.69	0.67	0.04	0.77	0.53	1.00	
G-BHC	0.56	0.59	0.62	0.03	0.71	0.44	0.73	1.00
	DCB	TCB	QCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC

Table K-3f

LCIC RANK CORRELATIONS FOR EDA SAMPLING AREA 6 [a]

N = 76 [b]

LCIC								
DCB	1.00							
TCB	0.58	1.00						
QCB	0.53	0.92	1.00					
CNP	0.33	0.31	0.33	1.00				
A-BHC	0.36	0.70	0.72	0.26	1.00			
D-BHC	0.23	0.34	0.36	0.04	0.32	1.00		
B-BHC	0.33	0.45	0.42	-0.01	0.37	0.42	1.00	
G-BHC	0.30	0.30	0.28	0.23	0.36	0.23	0.30	1.00
	DCB	TCB	QCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC

---

a. Correlations were computed by calculating correlations within laboratories and then averaging correlations across laboratories.

b. N denotes total sample size over all laboratories.

Table K-3g

LCIC RANK CORRELATIONS FOR EDA SAMPLING AREA 7 [a]

N = 65 [b]

LCIC	DCB	TCB	QCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC
DCB	1.00							
TCB	0.68	1.00						
QCB	0.59	0.93	1.00					
CNP	0.49	0.35	0.28	1.00				
A-BHC	0.34	0.57	0.58	0.17	1.00			
D-BHC	0.18	0.24	0.22	0.11	0.11	1.00		
B-BHC	0.18	0.38	0.43	0.05	0.45	0.17	1.00	
G-BHC	0.18	0.34	0.29	0.11	0.25	0.21	0.10	1.00

Table K-3h

LCIC RANK CORRELATIONS FOR CENSUS TRACT 221 [a]

N = 43 [b]

LCIC	DCB	TCB	QCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC
DCB	1.00							
TCB	0.47	1.00						
QCB	0.39	0.82	1.00					
CNP	0.56	-0.11	-0.15	1.00				
A-BHC	0.37	0.58	0.47	0.05	1.00			
D-BHC	0.08	0.14	0.14	-0.00	0.10	1.00		
B-BHC	0.21	0.33	0.28	-0.25	0.29	0.24	1.00	
G-BHC	0.01	0.28	0.18	-0.12	0.29	-0.05	0.11	1.00

---

a. Correlations were computed by calculating correlations within laboratories and then averaging correlations across laboratories.

b. N denotes total sample size over all laboratories.

Table K-3i

LCIC RANK CORRELATIONS FOR CENSUS TRACT 225 a

N = 52 b

LCIC								
DCB	1.00							
TCB	0.60	1.00						
QCB	0.60	0.91	1.00					
CNP	0.13	0.06	0.16	1.00				
A-BHC	0.34	0.53	0.52	0.30	1.00			
D-BHC	0.15	0.27	0.27	0.16	0.37	1.00		
B-BHC	0.37	0.47	0.49	0.07	0.60	0.35	1.00	
G-BHC	0.27	0.55	0.56	0.04	0.53	0.43	0.59	1.00
	DCB	TCB	QCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC

Table K-3j

LCIC RANK CORRELATIONS FOR CHEEKTOWAGA AND TONAWANDA

N = 46 b

LCIC								
DCB	1.00							
TCB	0.52	1.00						
QCB	0.21	0.66	1.00					
CNP	0.29	0.08	0.16	1.00				
A-BHC	0.16	0.08	0.02	0.01	1.00			
D-BHC	0.00	0.00	0.00	0.00	0.00	1.00		
B-BHC	0.06	0.03	0.01	-0.10	0.09	0.00	1.00	
G-BHC	0.09	0.07	0.02	0.02	-0.03	0.00	-0.03	1.00
	DCB	TCB	QCB	CNP	A-BHC	D-BHC	B-BHC	G-BHC

---

a. Correlations were computed by calculating correlations within laboratories and then averaging correlations across laboratories.

b. N denotes total sample size over all laboratories.

Table K-4

RESULTS OF NONPARAMETRIC UNIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD OR UNCERTAIN a,b,c,d

LCIC	Comparison Area	Median Conc (ppb)	EDA Sampling Areas							Comparison Areas		
			1	2	3	4	5	6	7	221	225	C&T
			1.01	0.41	0.42	0.38	0.39	0.36	0.41	0.40	0.42	0.36
DCB	221	0.40	++	o	o	--	o	- (--)	o		o	--
	225	0.42	++	o	o	o (-)	o	o	o	o		o
	C&T	0.36	++	+ (++)	++	o	o	o	+	++	o	
			8.67	0.88	0.89	0.45	0.57	0.38	0.59	0.64	0.60	0.14
TCB	221	0.64	++	++	++ (+)	-	o	--	o		o	--
	225	0.60	++	+ (++)	+	o	o	--	o	o		--
	C&T	0.14	++	++	++	++	++	++	++	++	++	
			12.93	1.12	1.07	0.42	0.46	0.32	0.55	0.55	0.64	0.05
QCB	221	0.55	++	++	++	o (-)	o	--	o		o	--
	225	0.64	++	++	++	o	o	--	o	o		--
	C&T	0.05	++	++	++	++	++	++	++	++	++	
			ND	0.04	ND	0.04	0.06	0.05	0.05	0.06	0.07	0.03
CNP	221	0.06	o	o	o	o	o	o	o		o	o
	225	0.07	-	-	- (--)	o	-	o	o	o		-
	C&T	0.03	o	o	o	o	o	o	+	o	+	
			9.47	0.36	0.22	0.12	0.14	0.07	0.15	0.18	0.11	ND
A-BHC	221	0.18	++	++	+ (o)	o	o	-	o		o	--
	225	0.11	++	++	o	o	o	o	o	o		--
	C&T	ND	++	++	++	++	++	++	++	++	++	
			1.20	ND	ND	ND	ND	ND	ND	ND	ND	ND
D-BHC	221	ND	++	++	++	++ (+)	+	o	o		+ (o)	o
	225	ND	++	++	o	o	o	o	o	- (o)		--
	C&T	ND	++	++	++	++	++	+ (++)	++	o	++	
			11.68	0.19	0.07	ND	ND	ND	ND	ND	ND	ND
B-BHC	221	ND	++	++	++	+	o	o	o		+	--
	225	ND	++	o	o	o	o	--	o	-		--
	C&T	ND	++	++	++	++	++	++	++	++	++	
			1.73	0.05	ND	ND	ND	ND	ND	ND	ND	ND
G-BHC	221	ND	++	++	++	+	o	o	o		+ (o)	- (--)
	225	ND	++	+	o	o	o	-- (-)	o	- (o)		--
	C&T	ND	++	++	++	++	++	++	++	+	++	
TOTALS	++		21	15	13	7	6	5	6	5	6	0
	+		0	3	2	2	1	1	2	1	4	0
	o		2	5	8	13	16	10	16	7	6	3
	-		1	1	1	1	1	2	0	3	0	2
	--		0	0	0	1	0	6	0	0	0	11
All Symbols			24	24	24	24	24	24	24	16	16	16

---

a. ++: EDA > Comparison area at 0.01 significance level
+: EDA > Comparison area at 0.05 significance level
o: No significant difference at 0.05 significance level
-: EDA < Comparison area at 0.05 significance level
--: EDA < Comparison area at 0.01 significance level

b. All test results reported are based on two-sided p-values.

c. The first entry in each column is median concentration. ND indicates non-detect.

d. Any change in results between GOOD and GOOD + UNCERTAIN is indicated by two sets of symbols; the second set of symbols denotes the original result for the GOOD observations.

e. C&T = Cheektowaga and Tonawanda
221 = Census Tract 221
225 = Census Tract 225

*

Table K-5

RESULTS OF NONPARAMETRIC MULTIVARIATE STATISTICAL COMPARISONS
WITH OBSERVATIONS CLASSIFIED AS GOOD OR UNCERTAIN a,b,c

Comparison Area	EDA Sampling Areas							Comparison Areas		
	1	2	3	4	5	6	7	221	225	C&T
221	++	++	++	--	- (+)	--	-- (++)		++ (+)	--
225	++	++	o (+)	o	-	-- (-)	o	-- (-)		--
C&T	++	++	++	++	++	++	++	++	++	

---

a. ++: EDA > Comparison area at 0.01 significance level
+: EDA > Comparison area at 0.05 significance level
o: No significant difference at 0.05 significance level
-: EDA < Comparison area at 0.05 significance level
--: EDA < Comparison area at 0.01 significance level

b. The direction of the difference between the EDA and Comparison areas is based on the sign of the sum of the elements of the 8 x 1 vector of rank-sums (See Appendix B).

c. Any change in results between GOOD and GOOD + UNCERTAIN is indicated by two sets of symbols; the second set of symbols denotes the original result for the GOOD observations.

d. C&T = Cheektowaga and Tonawanda
221 = Census Tract 221
225 = Census Tract 225

Table K-6

SUMMARY OF NONPARAMETRIC UNIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD OR UNCERTAIN a,b

Totals over all LCICs

Comparison Area		EDA Sampling Areas							Comparison Areas		
		1	2	3	4	5	6	7	221	225	C&T
CT221	++	7	6	5	1	0	0	0		0	0
	+	0	0	1	2	1	0	0		3	0
	o	1	2	2	3	7	4	8		5	2
	-	0	0	0	1	0	2	0		0	1
	--	0	0	0	1	0	2	0		0	5
CT225	++	7	3	1	0	0	0	0	0		0
	+	0	2	1	0	0	0	0	0		0
	o	0	2	5	8	7	4	8	5		1
	-	1	1	1	0	1	0	0	3		1
	--	0	0	0	0	0	4	0	0		6
C&T	++	7	6	7	6	6	5	6	5	6	
	+	0	1	0	0	0	1	2	1	1	
	o	1	1	1	2	2	2	0	2	1	
	-	0	0	0	0	0	0	0	0	0	
	--	0	0	0	0	0	0	0	0	0	

---

a. ++: EDA > Comparison area at 0.01 significance level
+: EDA > Comparison area at 0.05 significance level
o: No significant difference at 0.05 significance level
-: EDA < Comparison area at 0.05 significance level
--: EDA < Comparison area at 0.01 significance level

b. All test results reported are based on two-sided p-values.

c. C&T = Cheektowaga and Tonawanda
221 = Census Tract 221
225 = Census Tract 225

Table K-7

TWO-SIDED p-VALUES FOR THE UNIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD OR UNCERTAIN

LCIC	Comparison Area	EDA Sampling Areas 1	2	3	4	5	6	7	Comparison Areas 221	225	C&T
DCB	221	0.000	0.802	0.992	0.004	0.389	0.016	0.546	1.000	0.359	0.002
	225	0.000	0.301	0.201	0.210	0.468	0.657	0.318	0.359	1.000	0.318
	C&T	0.000	0.013	0.000	0.833	0.098	0.114	0.025	0.002	0.318	1.000
TCB	221	0.000	0.003	0.006	0.019	0.263	0.000	0.123	1.000	0.330	0.000
	225	0.000	0.015	0.029	0.192	0.787	0.004	0.910	0.330	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
QCB	221	0.000	0.000	0.000	0.081	0.429	0.000	0.496	1.000	0.333	0.000
	225	0.000	0.000	0.007	0.105	0.248	0.000	0.832	0.333	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
CNP	221	0.086	0.051	0.083	0.501	0.258	0.426	0.927	1.000	0.910	0.095
	225	0.044	0.023	0.016	0.139	0.018	0.412	0.745	0.910	1.000	0.014
	C&T	0.609	0.877	0.695	0.125	0.653	0.155	0.033	0.095	0.014	1.000
A-BHC	221	0.000	0.000	0.029	0.638	0.361	0.010	0.748	1.000	0.393	0.000
	225	0.000	0.001	0.277	0.391	0.978	0.064	0.713	0.393	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
D-BHC	221	0.000	0.000	0.000	0.006	0.012	0.523	0.144	1.000	0.034	0.291
	225	0.000	0.001	0.191	0.428	0.817	0.201	0.567	0.034	1.000	0.004
	C&T	0.000	0.000	0.000	0.000	0.001	0.036	0.007	0.291	0.004	1.000
B-BHC	221	0.000	0.000	0.000	0.010	0.290	0.308	0.076	1.000	0.014	0.000
	225	0.000	0.071	0.588	0.961	0.147	0.000	0.347	0.014	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	1.000
G-BHC	221	0.000	0.000	0.000	0.015	0.154	0.933	0.270	1.000	0.021	0.015
	225	0.000	0.045	0.349	0.759	0.366	0.006	0.058	0.021	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.015	0.000	1.000

a. C&T = Cheektowaga and Tonawanda
221 = Census Tract 221
225 = Census Tract 225

Table K-8

TWO-SIDED p-VALUES FOR NONPARAMETRIC MULTIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD OR UNCERTAIN

Comparison Area	EDA Sampling Areas							Comparison Areas		
	1	2	3	4	5	6	7	221	225	C&T
221	0.000	0.000	0.000	0.000	0.017	0.000	0.002	1.000	0.004	0.000
225	0.000	0.000	0.077	0.123	0.037	0.009	0.777	0.004	1.000	0.000
C&T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000

a. C&T = Cheektowaga and Tonawanda
221 = Census Tract 221
225 = Census Tract 225

Table K-9

RESULTS OF NONPARAMETRIC UNIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD a,b,c,d

All observations <= 1 ppb treated as Non-detect

LCIC	Comparison Area	Median Conc (ppb)	EDA Sampling Areas 1	2	3	4	5	6	7	Comparison Areas 221	225	C&T
			1.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
DCB	221	ND	++	o	o	o (--)	o	o (--)	- (o)		o	o (--)
	225	ND	++	o	o	o (-)	o	o	o	o		o
	C&T	ND	++	o (++)	o (++)	o	o	o	o (+)	o (++)	o	
			8.67	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCB	221	ND	++	++	++ (+)	o (-)	o	--	o		o	--
	225	ND	++	o (++)	o (+)	o	o	--	o	o		--
	C&T	ND	++	++	++	++	++	o (++)	++	++	++	
			11.48	1.17	1.06	ND	ND	ND	ND	ND	ND	ND
QCB	221	ND	++	++	++	+ (-)	++ (o)	o (--)	++ (o)		++ (o)	- (--)
	225	ND	++	++	+ (++)	o	o	--	o	-- (o)		--
	C&T	ND	++	++	++	++	++	o (++)	++	+ (++)	++	
			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CNP	221	ND	o	o	o	o	o	o	o		o	o
	225	ND	o (-)	o (-)	o (--)	o	o (-)	o	o	o		o (-)
	C&T	ND	o	o	o	o	o	o	o (+)	o	o (+)	
			8.25	ND	ND	ND	ND	ND	ND	ND	ND	ND
A-BHC	221	ND	++	++	++ (o)	++ (o)	+ (o)	o (-)	o		+ (o)	o (--)
	225	ND	++	o (++)	o	o	o	- (o)	-- (o)	- (o)		--
	C&T	ND	++	++	++	++	++	o (++)	o (++)	o (++)	++	
			1.13	ND	ND	ND	ND	ND	ND	ND	ND	ND
D-BHC	221	ND	++	o (++)	o (++)	o (+)	o (+)	o	o		o	o
	225	ND	++	o (++)	o	o	o	o	o	o		o (--)
	C&T	ND	++	o (++)	o (++)	o (++)	o (++)	o (++)	o (++)	o	o (++)	
			11.58	ND	ND	ND	ND	ND	ND	ND	ND	ND
B-BHC	221	ND	++	++	+ (++)	++ (+)	+ (o)	o	o		+	o (--)
	225	ND	++	o	o	o	o	o (--)	o	-		- (--)
	C&T	ND	++	++	++	++	+ (++)	o (++)	o (++)	o (++)	+ (++)	
			1.73	ND	ND	ND	ND	ND	ND	ND	ND	ND
G-BHC	221	ND	++	o (++)	o (++)	o (+)	o	o	o		o	o (--)
	225	ND	++	o (+)	o	o	o	-	- (o)	o		- (--)
	C&T	ND	++	++	+ (++)	o (++)	+ (++)	o (++)	o (++)	o (++)	+ (++)	
TOTALS	++		21	10	7	6	4	0	3	1	4	0
	+		0	0	3	1	4	0	0	1	4	0
	o		3	14	14	17	16	19	18	11	8	9
	-		0	0	0	0	0	2	2	2	0	3
	--		0	0	0	0	0	3	1	1	0	4
All Symbols			24	24	24	24	24	24	24	16	16	16

---

a. ++: EDA > Comparison area at 0.01 significance level
+: EDA > Comparison area at 0.05 significance level
o: No significant difference at 0.05 significance level
-: EDA < Comparison area at 0.05 significance level
--: EDA < Comparison area at 0.01 significance level

b. All test results reported are based on two-sided p-values.

c. The first entries in each column are median concentrations. ND indicates non-detect.

d. Any changes in results between the original analysis and this analysis is indicated by two sets of symbols; the second set of symbols denotes the original results for the GOOD observations.

e. C&T = Cheektowaga and Tonawanda
221 = Census Tract 221
225 = Census Tract 225

Table K-10

SUMMARY OF NONPARAMETRIC UNIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD a,b

All observations <= 1 ppb treated as non-detect

Totals over all LCICs

Comparison Area		EDA Sampling Areas							Comparison Areas		
		1	2	3	4	5	6	7	221	225	C&T
CT221	++	7	4	3	2	1	0	1		1	0
	+	0	0	1	1	2	0	0		2	0
	o	1	4	4	5	5	7	6		5	6
	-	0	0	0	1	0	0	1		0	1
	--	0	0	0	1	0	1	0		0	1
CT225	++	7	1	0	0	0	0	0	0		0
	+	0	0	1	0	0	0	0	0		0
	o	1	7	7	8	8	4	6	5		3
	-	0	0	0	0	0	2	1	2		2
	--	0	0	0	0	0	2	1	1		3
C&T	++	7	5	4	4	3	0	2	1	3	
	+	0	0	1	0	2	0	0	1	2	
	o	1	3	3	4	3	8	6	6	3	
	-	0	0	0	0	0	0	0	0	0	
	--	0	0	0	0	0	0	0	0	0	

---

a. ++: EDA > Comparison area at 0.01 significance level
+: EDA > Comparison area at 0.05 significance level
o: No significant difference at 0.05 significance level
-: EDA < Comparison area at 0.05 significance level
--: EDA < Comparison area at 0.01 significance level

b. All test results reported are based on two-sided p-values.

c. C&T = Cheektowaga and Tonawanda
221 = Census Tract 221
225 = Census Tract 225

Table K-11

TWO-SIDED p-VALUES FOR THE UNIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD

All observations <= 1 ppb treated as Non-detect

LCIC	Comparison Area	EDA Sampling Areas 1	2	3	4	5	6	7	Comparison Areas 221	225	C&T
DCB	221	0.000	0.201	0.500	0.435	0.456	0.534	0.019	1.000	0.495	0.693
	225	0.000	0.112	0.186	0.971	0.190	0.697	0.095	0.495	1.000	0.629
	C&T	0.000	0.126	0.128	0.678	0.189	0.809	0.052	0.693	0.629	1.000
TCB	221	0.000	0.000	0.001	0.585	0.080	0.009	0.486	1.000	0.121	0.000
	225	0.000	0.056	0.352	0.260	0.969	0.000	0.241	0.121	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.063	0.000	0.000	0.000	1.000
QCB	221	0.000	0.000	0.000	0.022	0.005	0.759	0.006	1.000	0.003	0.030
	225	0.000	0.002	0.043	0.408	0.778	0.000	0.405	0.003	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.063	0.000	0.030	0.000	1.000
CNP	221	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	225	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	C&T	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
A-BHC	221	0.000	0.001	0.007	0.001	0.041	0.949	0.963	1.000	0.016	1.000
	225	0.000	0.219	0.756	0.421	0.740	0.011	0.010	0.016	1.000	0.005
	C&T	0.000	0.000	0.002	0.001	0.005	0.251	0.258	1.000	0.005	1.000
D-BHC	221	0.000	0.162	0.141	0.205	0.255	0.508	0.398	1.000	0.289	1.000
	225	0.000	0.454	0.487	0.755	0.728	0.814	0.786	0.289	1.000	0.317
	C&T	0.000	0.113	0.078	0.335	0.165	0.386	0.423	1.000	0.317	1.000
B-BHC	221	0.000	0.001	0.013	0.004	0.028	0.861	0.269	1.000	0.042	1.000
	225	0.000	0.165	0.512	0.182	0.805	0.056	0.421	0.042	1.000	0.050
	C&T	0.000	0.001	0.004	0.001	0.024	0.792	0.251	1.000	0.050	1.000
G-BHC	221	0.000	0.086	0.220	0.206	0.097	0.182	0.169	1.000	0.203	0.317
	225	0.000	0.551	0.925	0.862	0.627	0.013	0.010	0.203	1.000	0.050
	C&T	0.000	0.009	0.017	0.063	0.016	1.000	1.000	0.317	0.050	1.000

a. C&T = Cheektowaga and Tonawanda
221 = Census Tract 221
225 = Census Tract 225

Table K-12

TWO-SIDED p-VALUES FOR THE UNIVARIATE STATISTICAL COMPARISONS WITH OBSERVATIONS CLASSIFIED AS GOOD

All observations <= 1 ppb treated as Non-detect

LCIC	Comparison Area	EDA Sampling Areas							Comparison Areas		
		1	2	3	4	5	6	7	221	225	C&T
DCB	221	0.000	0.201	0.500	0.435	0.456	0.534	0.019	1.000	0.495	0.693
	225	0.000	0.112	0.186	0.971	0.190	0.697	0.095	0.495	1.000	0.629
	C&T	0.000	0.126	0.128	0.678	0.189	0.809	0.052	0.693	0.629	1.000
TCB	221	0.000	0.000	0.001	0.585	0.080	0.009	0.486	1.000	0.121	0.000
	225	0.000	0.056	0.352	0.260	0.969	0.000	0.241	0.121	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.063	0.000	0.000	0.000	1.000
QCB	221	0.000	0.000	0.000	0.022	0.005	0.759	0.006	1.000	0.003	0.030
	225	0.000	0.002	0.043	0.408	0.778	0.000	0.405	0.003	1.000	0.000
	C&T	0.000	0.000	0.000	0.000	0.000	0.063	0.000	0.030	0.000	1.000
CNP	221	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	225	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	C&T	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
A-BHC	221	0.000	0.001	0.007	0.001	0.041	0.949	0.963	1.000	0.016	1.000
	225	0.000	0.219	0.756	0.421	0.740	0.011	0.010	0.016	1.000	0.005
	C&T	0.000	0.000	0.002	0.001	0.005	0.251	0.258	1.000	0.005	1.000
D-BHC	221	0.000	0.162	0.141	0.205	0.255	0.508	0.398	1.000	0.289	1.000
	225	0.000	0.454	0.487	0.755	0.728	0.814	0.786	0.289	1.000	0.317
	C&T	0.000	0.113	0.078	0.335	0.165	0.386	0.423	1.000	0.317	1.000
B-BHC	221	0.000	0.001	0.013	0.004	0.028	0.861	0.269	1.000	0.042	1.000
	225	0.000	0.165	0.512	0.182	0.805	0.056	0.421	0.042	1.000	0.050
	C&T	0.000	0.001	0.004	0.001	0.024	0.792	0.251	1.000	0.050	1.000
G-BHC	221	0.000	0.086	0.220	0.206	0.097	0.182	0.169	1.000	0.203	0.317
	225	0.000	0.551	0.925	0.862	0.627	0.013	0.010	0.203	1.000	0.050
	C&T	0.000	0.009	0.017	0.063	0.016	1.000	1.000	0.317	0.050	1.000

a. C&T = Cheektowaga and Tonawanda
221 = Census Tract 221
225 = Census Tract 225

Table K-13

Simulated power (at alpha = 0.05) for univariate tests

	LCIC							
Delta	1	2	3	4	5	6	7	8
0.00	.050	.050	.050	.044	.048	.056	.058	.042
0.05	.122	.088	.086	.140	.062	.076	.074	.070
0.10	.244	.144	.130	.322	.096	.088	.104	.084
0.20	.616	.286	.254	.756	.136	.124	.152	.156
0.50	.988	.808	.756	1.000	.338	.354	.412	.452
1.00	1.000	.990	.982	1.000	.676	.740	.808	.832
2.00	1.000	1.000	1.000	1.000	.958	.984	.994	.998
5.00	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

a. Estimated parameters for power simulation from "good" soil LCIC study data.

b. LCIC concentrations in EDA sampling areas are drawn from a statistical population related to that of the comparison area by the factor 1+delta; delta = 10.0 corresponds to an order of magnitude shift. The goal for the soil LCIC study was to have a power of 0.90 at a delta of 10.0.

Table K-14

Simulated power for multivariate test

			ALPHA		
	.0100	.0250	.0500	.1000	.2000
Deltaa					
.00	.000	.006	.022	.066	.176
.05	.000	.000	.022	.072	.192
.10	.000	.004	.034	.102	.216
.20	.014	.048	.096	.174	.340
.50	.256	.402	.528	.656	.808
1.00	.920	.968	.990	.994	.998
2.00	1.000	1.000	1.000	1.000	1.000
5.00	1.000	1.000	1.000	1.000	1.000
10.00	1.000	1.000	1.000	1.000	1.000

a. Estimated parameters for power simulation from "good" soil LCIC study data.

b. LCIC concentrations in EDA sampling areas are drawn from a statistical population related to that of the comparison area by the factor 1+delta; delta = 10.0 corresponds to an order of magnitude shift. The goal for the soil LCIC study was to have a power of 0.90 at a delta of 10.0.